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RESOURCES AND COMMERCE OF THE ARGENTINE REPUBLIC.

THE Argentine Republic is one of the most progressive nations of South America. In a remarkably short space of time the Republic has attained to a phenomenal state of civilization. It extends north and south a distance of 2,400 miles and the average breadth is about 700 miles. The climate is generally healthy, the soil fertile and very productive. Along the banks of the rivers are valuable forests, while on the rich plains millions of cattle roam. The principal productions of the country are wool, hides, maize, hay, linseed, flour, beef, sugar, wine, grease, tallow and bones. In the year 1888 there were over 70,000,000 sheep, 22,000,000 horned cattle and 4,398,283 horses. Agriculture is also advancing by rapid strides. In 1889, 5,899,859 acres of land were under cultivation; in 1891 the cultivated area had increased to 6,700,000 acres, so that material progress has been made in even two years. Mining is also an important industry. From these figures it will be seen that the resources of the Argentine Republic are very great, and it is one of the most prosperous of the South American republics. The population of the Republic was 3,794,000 in 1889. In March, 1892, the total railway mileage opened for traffic was 7,676 miles, serving nearly all parts of the country. There are many roads now under survey. The great Transandine road is one of the modern wonders of the world In 1892 there were 70,415 miles of telegraph lines in operation, and in the preceding year 2,340,000 dispatches were sent. In 1890 over 60,000,000 letters were sent and received.

From the perusal of these figures some idea may be obtained of the state of civilization existing in this new country. In our illustration, for which we are indebted to La Ilustracion Sud-Americana, one of the busy scenes at the docks on the Riachuelo River at Buenos Ayres is shown. Buenos Ayres, the capital of the Argentine Republic, is situated on the right bank of the estuary of the La Plata River. The river at this point is so wide that it is quite impossible with the naked eye to distinguish the opposite bank. The river and estuary is unfortunately very shallow. The Riachuelo River falls into the great estuary near the city. The population of Buenos Ayres now exceeds 220,000, which was the population in 1876. The city contains handsome public buildings, churches and houses; it is provided with drainage and water supply and is lighted by gas and electricity and served by numerous tramyals. The commerce of the Argentine Republic is considerable. The exports amount to more than $108,000,000. Financial troubles crippled the country for some time, but now the nation seems to have entered on a period of industrial and commercial regeneration.

VIEW IN BUENOS AYRES, ARGENTINE REPUBLIC.

[FROM THE NEW YORK SUN.]

A TRIP TO MOUNT TACOMA.

THE mountaineering season in the State of Washington is short, rarely extending beyond the months of July and August. In time, when comfortable hotels are located at proper points, the season may be doubled in length, but at present everything, tents, blankets, and provisions, must be carried along, and it is therefore, even aside from the dangers, more difficult to conquer some of our peaks than those of the Alps, where trained guides are plentiful and routes well known.

The large amount of travel to Mount Tacoma during recent years has forced the building of a road which now extends from the city of Tacoma almost to the base of the mountain, sixty-five miles being necessary to cover the air line distance of forty-four miles to Paradise Park, which lies on the south flank of the mountain, and covers about ten square miles. The entire mountain base covers over two hundred square miles, from which the mass of the giant rises as one majestic and solitary peak, with a rounded, dome-like summit 15,000 feet above the sea. Its wonderful system of glaciers is already famed as being the greatest belonging to any single mountain upon the globe.

In order to complete some geological surveys it became necessary to make a trip to the mountain last month and to go by a new route and explore a part of the mountain very little known—the great Carbon Glacier, on the north slope, which gets its name from the river which it heads, which river traverses some great coal fields in its journey to Puget Sound. Of course there was some novelty to this late trip, and the party was soon made up, comprising Assistant Harry M. Sarvant, Photographer Heath, and two members of the Indian Commission—James J. Anderson and Ross J. Alexander, who were so hungry for a mountain trip that dangers and hardships were entirely forgotten.

From the little mining town of Wilkeson, where the railroad ends, our route lay through very dense forests for nine miles, following a good trail to the Carbon River. This was the same trail traveled by Mr. Garrett P. Serviss, the astronomer, two years before, when with the writer he made the journey from Tacoma to the mountain and return in three days, the quickest trip on record. At Carbon River, however, we left the trail and followed up the river bottom, crossing from one gravel bar to another by fording through the ice cold and milky glacial water, or jumping from rock to rock where we could. At sunset we were not sorry to find a mossy bank where we could pitch the tent and spread our blankets, even though the river and a neighboring waterfall over 100 feet high made a deafening noise, which, under other conditions, would have prevented sleep.

Four miles of very hard walking, which required as many hours, brought us to the foot of the great glacier, where we were glad to throw off our heavy packs and take rest and food. The face of the glacier was an almost perpendicular wall of ice, between two and three hundred feet high, and looked deep blue in color. The river issued, full grown, from a great arch at the base and rushed down the heavy grade of the valley with a force which carried great bowlders with it. With some difficulty we scaled the face of the glacier where it was lowest and where sharp, angular rocks were firmly held by the ice and furnished us a safe foothold. The glacier lay in a deep canon of volcanic rock, and was for the lower mile completely covered with morainic debris. All the rocks were angular and of every size, and ranged in hardness from the softest pumice to obsidian.

Looking down the glacier the view was very fine,

for the Carbon Valley is lined with "hills" higher than any of the lofty "mountain peaks" of the Eastern States, and we were almost up to their level. To the southward the grand old mountain was in plain view, and made the rest of the country look flat by comparison.

The carbon glacier does not flow straight, but follows several curves of its "cradle," and is therefore deeply rent into crevasses, and the straining ice often shows beautiful colors where it thwarts the sun's rays. As we proceeded these crevasses became very numerous; indeed, there were soon more fissures than surface, and we were compelled to pick our way with considerable care along ridges and snow spans. One of our guests had to be pulled out of a crevasse to the edge of which he had clung as he slipped, and our other guest was frequently heard to remark that if he ever got away from there he would never leave home again. Now that he is safe at home he is planning for another trip next season.

It was quite dark when we got off the glacier, and, climbing a steep moraine, found ourselves in a little sheltered spot, with wood and water sufficient for our needs. Many persons make the mistake of eating ice and snow when on the mountain, and bring upon themselves the torture of thirst, sore mouths, and stomach aches—a diversion we were not courting. The following day, after some scouting, we moved camp to a beautiful park at an elevation of 6,000 feet, where the scenery was superb, even for this region of wonderful views. Below to the westward was the Carbon glacier and beyond it a great snow covered divide, beyond which were the Mowich glacier and Spray Park. To the northwest the view passed over great areas of jagged pinnacles of foot hills, past the beautiful prairies near the city of Tacoma, over the city itself near the silvery Puget Sound, and far beyond to the Olympic Mountains, 150 miles away. Northward was the Sluiskin range of volcanic peaks, while to the northeast the Cascade Mountains stretched as far as we can see like great waves of an ocean. A thousand feet below us to the east was the Winthrop glacier, another great river of ice nearly as large as the Carbon. All this we could see from our tent door, and a great deal more, for the entire southern field of view and far up toward the zenith was filled by the majestic snow-covered form of Mount Tacoma. If one desires to learn the utter poverty of our language, he may try to describe this mountain. Fifty-four East River bridge towers would not reach its height, nor would greater New York contain its base.

We were partially protected by a stunted growth of mountain firs, and a beautiful little lake furnished water. We built a fireplace of lava chips, and made our beds of juniper and heather. Silence was often broken by the roar of an avalanche, the sharp crack a glacier, or the crash of falling rocks. Often the shrill whistle of a marmot would be heard, for these little mountaineers are numerous, and with the white goats and wolves are the principal fauna. They often weigh as much as twenty pounds, and are considered good eating by many.

Our evenings were spent in the cozy tent telling stories, playing whist, or reading. Sometimes the midnight winds threatened to blow us off the mountain, and it required considerable faith in our large but light tent to slumber under such conditions. During the days we made excursions in all directions, on one occasion climbing the divide to an elevation of 9,000 feet. Our route lay along the right bank of the Carbon glacier, and we made a special study of it. The flow of the ice is well illustrated here, for the bed or cradle is in places very uneven, and is twice crossed by granite dikes, which produce great cataracts of ice. Below, for some distance, the surface of the glacier would be badly torn, but after flowing a mile or more would again be smooth, only to be again broken when another obstruction was met. At one of the sharp bends of the glacier the crevasses were of awful depth, and the ice and snow had assumed the most grotesque of forms. At many places great snow fields, lying on the steep divides, fed the glacier or overhung the cliffs, ready to drop on the slightest provocation. We were far above the timber line, and the entire length of the great glacier was exposed to our view with all its moraines clearly defined. At one point we stopped for half an hour to push great rocks over a 500 foot cliff, and watch them fall upon the glacier below. It was perhaps undignified sport for a scientific party, but it was fun.

Once the clouds formed below us so thickly that they looked like a foaming sea extending to the Olympic Mountains and covering the Cascade range, with the exception of its highest peaks. It was a beautiful sight, but very disappointing to us, for the Monterey was to be at the port of Tacoma that evening, and we expected to be able to see the effect of her search lights thrown upon the mountain from a distance of forty-four miles.

At an elevation of 8,000 feet we got a magnificent view of the head of the glacier where it lay against the mountain slope over 3,000 feet higher than we were. It was fed directly from the snow cap of the mountain, and while we were looking at it a great mass of snow fell from its proud position as a great cloud of vapor down the steep face of the mountain upon the glacier. If any of our party expressed a desire to see one of these avalanches at close quarters, the writer did not hear it.

We were soon almost in front of a great fall in the glacier where it was much torn by its rough bed, and there obtained an excellent photograph before we were cut off by clouds, which prevented any further work that day and compelled us to make a hasty retreat down to camp. When we began our homeward journey we crossed the Carbon glacier, and ascending its steep lateral moraine with the help of a rope, made our way against a storm over into Spray Park, where we found a deserted camp of mountain climbers who had left the month before. We reached Tacoma in three days.

What a pity that we had not delayed our trip and seen the slight eruption which so many persons have claimed to have seen on Nov. 21 and 22, when the clouds would part so that the top of the mountain could be observed for a few moments. There is no good reason for denying that the many persons in various localities saw volumes of smoke coming from the summit. Several eruptions of smoke have been witnessed in early days, and steam is always issuing from the crater. Let us hope that we will be treated to a first-class eruption in the near future, for there is nothing to be feared and much to be seen.

FRED G. PLUMMER.

[FROM POPULAR ASTRONOMY.]

THE PLANET JUPITER.

By G. W. HOUGH.

On the 7th of January, 1610, Galileo casually examined Jupiter with a new telescope which he had constructed, and was surprised to see three bright stars near the planet, arranged in a row, one on the right and two on the left.

On the next night he saw three stars, all on the right side, which he thought strange, since the planet should have moved in the opposite direction.

On the 10th he saw only two stars and both were on the left side. He suspected that the third was hidden by the planet and surmised that the stars were attendants on Jupiter.

On the 13th of January, he finally saw four stars and justly concluded that the planet was attended by four moons or satellites.

The configurations of the satellites of Jupiter, as given by Galileo, are of interest as being the first recorded positions of these bodies. The satellites are not visible to the naked eye, except in very rare cases.

The rays of light which are seen by most eyes about a bright star completely obliterate the minute satellite. It is only to an abnormal eye, to which the star appears as a round disk, that the visibility of a satellite is possible.

There are two or three authentic cases of persons having seen a satellite of Jupiter with the unaided eye.

When sufficient optical power is used, however, the satellites appear as round well defined disks which may be measured with the micrometer.

The following table gives the period of revolution, distance and size of satellites:

Satellites.	Distance Miles.	Sidereal Period. d.	h.	Apparent Diameter. ″
I	267,000	1	18·5	1·07
II	425,000	3	13·3	0·95
III	678,000	7	04·0	1·59
IV	1,193,000	16	18·1	1·39

The linear value of 1″ of arc at the mean distance of Jupiter is 2,330 miles; hence satellites I and II are nearly the same size as our moon.

The satellites in their revolution around the planet give rise to a number of interesting phenomena, viz., eclipses, transits and occultations. When a satellite passes into the shadow cast by the planet, it is eclipsed in the same way as the moon is eclipsed by passing into the shadow of the earth.

Very soon after their discovery it was pointed out that the eclipses might be employed for the determination of longitude, provided the time of the phenomenon could be computed for some definite meridian.

This method of getting longitude is not very exact, however, for the reason that as the satellite passes into the shadow it does not disappear instantaneously, but may be seen for a considerable interval, depending on the power of the telescope used. From the observation of the eclipses, Roemer was led to the great discovery of the velocity of light in space. He found as Jupiter receded from the earth, the eclipses occurred later and later, and finally concluded that it required 22 minutes for light to travel across the earth's orbit.

The satellites when they pass behind the disk of the planet are said to be occulted.

The most interesting phenomena connected with these bodies are their transits across the disk of the planet. When the satellite is fully projected on the disk it may be seen as a round white spot, which gradually grows fainter as it advances farther on the disk until its light becomes of equal intensity with that of the disk itself, when it ceases to be visible. After traversing the central portion of the disk it again becomes visible, before leaving the disk on the opposite side.

With the 18½ inch refractor of the Dearborn Observatory, the satellite may be followed one-fourth of the distance across the disk before it ceases to be visible, and when the passage occurs near the poles of the planet it may be seen during the whole transit. Occasionally the satellites in transit are seen as dark spots during the entire passage across the disk. This appearance is supposed to be due to dark patches on the satellite, or in other words, the side of the satellite turned toward the earth reflects less light than the planet itself.

The satellite casts a shadow which is seen to cross the disk as an oval black spot. The shadow is not quite round, because it is projected on a surface inclined to the line of sight.

Near the time of opposition a satellite and its shadow are in close proximity; at other times the satellite precedes or follows the shadow by a greater or less interval.

Occasionally stars bright enough to be observed are occulted by the planet. A number of such phenomena have been recorded.

On the 21st of March, 1860, the writer, observing with the 12 inch refractor of the Cincinnati Observatory, witnessed an expected emersion of a 9th magnitude star, and also an occultation of the same star by the first satellite. In passing behind the satellite the star remained invisible for eight minutes. (Brunnow's Astronomical Notices, No. 17.)

From the changes in brightness in different parts of their orbits, Sir Wm. Herschel concluded that the satellites revolved on their axes in the same time that they made a revolution around the planet.

For more than two and a half centuries the four moons of Jupiter were supposed to be the only attendants on that body; but on the 9th of September, 1892, Professor E. E. Barnard, with the 36 inch telescope of the Lick Observatory, detected a very faint star near the planet, which subsequently proved to be a fifth satellite. This body is exceedingly small and faint and can only be seen with the largest telescopes.

After the announcement of its discovery by Professor Barnard, and before the correct period of revolution had been ascertained, the writer saw it on two nights with the 18½ inch; and so far as is known this is the smallest aperture with which it hitherto has been seen.

Jupiter is a conspicuous object to the naked eye; being brighter than Mars or Saturn, but not quite equal to Venus. Under favorable conditions it may be seen during daylight when the sun is yet above the horizon.

The planet revolves around the sun in a period of 11¾ years at a mean distance of 5·2 times that of the earth from the sun. At his nearest approach to the earth, at opposition, his distance is about 400 millions of miles. On account, however, of the ellipticity of the orbits of the two planets, this distance may vary to the extent of 25 millions of miles.

The disk of the planet as seen in the telescope is distinctly oval, the largest diameter of the ellipse coinciding with the planet's equator. The mean diameter is about 87,000 miles and the equatorial diameter 90,000 miles.

The telescopes of Galileo were not of sufficient power to show markings on the disk; but in 1630 Zucchi saw that the disk was crossed by dark belts which were arranged parallel to the equator of the planet. The belts of Jupiter have been observed by all subsequent astronomers and are a permanent feature of the visible phenomena seen on the disk.

The equatorial belt is frequently mottled with white spots and markings, presenting a variety of detail very difficult to delineate. Besides the great belts which are always visible, there are fainter streaks, which are parallel to the equator and sometimes may be seen as far as 45 degrees of north and south latitude. Usually beyond 45 degrees of Jovian latitude there is a fine shading extending to the poles. Besides the belts, small oval white spots, 2,000 to 3,000 miles in diameter, are visible at every opposition in latitude 30° to 40° south, and occasionally also on the north side of the equator.

The most conspicuous spot of recent years is known as the great red spot of 1878. This object was of a reddish brick color of oval form, 30,000 miles in length and 8,000 miles in breadth, and was situated 19 degrees south of the planet's equator.

In the year 1665 Cassini observed a great spot near the margin of the southern equatorial belt. This object was observed by astronomers from 1665 to 1713, during which period it vanished and reappeared nine times, and on no occasion was the spot visible continuously for more than three years.

In 1860, Mr. Baxendall, of Manchester, England, published a drawing of Jupiter showing a depression in the south edge of the equatorial belt similar to the one found in recent years north of the great red spot.

In 1869–70 a number of observers delineated an oval spot south of the equatorial belt. As the great red spot of 1878 has been visible during a whole revolution of Jupiter around the sun, although at times so faint as to be seen with greatest difficulty, I think we are justified in considering it a permanent feature. Its change in distinctness is probably due to its greater or less submergence in the gaseous medium in which it floats. I think it highly probable that the great spot observed by Cassini in 1665, and also the spots of 1860–69, 1870–78, are all identical.

The minute history of this remarkable object, from 1878 to the present time, is beyond the scope of the present article. It may be stated, however, that the spot is not fixed, but it has been subject to a considerable drift in longitude and a slight shifting in latitude. The rotation time of the planet from observations of this spot in 1879 was 9 h. 55 m. 32·2 s., while during the past few years the rotation period has increased to 9 h. 55 m. 40 s. to 41 s. The spot has maintained essentially the same size and shape during the past fourteen years that it has been observed by the writer.

As to its physical constitution we have no definite knowlege. During the years 1879 to 1883 the spot was of a decided reddish brick color; but of late years it has been very much paler, and at times practically invisible. Assuming that the spot has a depth equal to its breadth, its volume would be about three times that of the earth.

The mean density of Jupiter is 1·37 times that of water and hence the surface density is probably only one-third as great, or 0·46, which would indicate a medium less dense than any known liquid.

As the great red spot shifts its position we infer that it floats in a medium which has a depth of at least 8,000 miles. From the observations of the transit of a satellite and also the shadow of a satellite over the red spot it is inferred that the spot reflects less light than the disk. The great red spot, the equatorial belt and other dark marking are probably of similar constitution.

If the planet is yet hot, as is often stated in recent works, the dark markings might be regarded as matter at a lower temperature than the rest of the surface.

The transits of satellites across the disk, however, prove conclusively that the central part of the disk of the planet reflects the same amount of light as the satellites and hence is not hot enough to have any inherent light of its own.

In the equatorial region, round white spots are seen at every opposition which have a drift of 250 miles per hour in the direction of the planet's rotation, corresponding to a rotation period of 9 h. 50 m. These spots are sometimes maintained with slight change of outline for a number of years, as was the case with two spots observed from 1879 to 1882.

As the axis of Jupiter is almost perpendicular to his orbit, the climate would be nearly constant during the whole Jovian year. It would be hot at the equator and cold at the poles.

This condition of climate offers an explanation of the greater changes taking place in the equatorial regions than in higher latitudes.

From the motions observed in both the white and dark spots, it is inferred that everything we see is floating in a medium having a depth measured by thousands of miles. That this medium is not atmospheric, as the term is usually understood, is apparent from two reasons.

1. The displacement in the great volumes of matter is usually slow.

2. The atmosphere cannot be of any considerable

depth, as compared with the diameter of the planet, because the edges of the disk present a sharp smooth outline. That there is an atmosphere overlying the denser medium is highly probable. This true atmosphere might subtend an angle of 1" of arc or 2,000 miles, without seriously affecting the definition of the limbs of the planet as seen through the telescope. The equatorial white spots and other matter, which has a drift of 250 miles per hour, for mechanical reasons must be located in the outer region of the planet's envelope.

The two principal rotation periods 9 h. 50 m. and 9 h. 56 m. are best accounted for by supposing that the whole outer layer of the planet's envelope, situated within 20° of the equator, moves in the direction of the planet's rotation with a velocity sufficient to complete a revolution around the planet in 45 days. All matter, either white or dark, situated in this envelope would be carried with it.

The period 9 h. 56 m. given by the great red spot, the equatorial belt and oval white spots distant from the equator, would be due to objects situated at a lower level in the gaseous medium.

July 3, 1880, shows the second satellite in transit over the great red spot. When the satellite touched the red spot it formed a notch, and when fully projected on the spot it appeared as white as when outside the disk of the planet.

A white spot near the equator, which was visible for a number of years.

The absence of belts or shadings, especially on the upper part of the disk, is due to the fact that the planet at that time was too far from the earth.

November 1, 1880, shows the shadow of the first satellite on the disk, and the shadow of the second satellite projected on the red spot. The shadow on the red spot was not quite as black as the shadow on the disk.

October 10, 1881, shows the great red spot and a peculiar spur under it, which was first seen by the writer on September 9, 1880 Also a minute black spot in the north polar region, and two oval white spots south of the great red spot.

April 5, 1884, shows the belt system, the great red spot, group of white spots south, three very minute white spots on the equatorial belt and three dusky patches.

It shows also, when compared with the previous sketches, very plainly the widening of the equatorial belt on the south margin.

During the past fourteen years, the equatorial belt and the great red spot did at no time come in contact. Although the belt drifted as far south as the center of the red spot, yet they remained separate.

The belt south of the red spot also moved north, but at no time was the spot actually in contact with it. May 2, 1886, shows the ring form of the great red spot, small white spots south, which are seen at every opposition, the equatorial belt, the fainter belts and the shadow of the second satellite.

The ring form of the great red spot was first seen by the writer on February 27, 1885, and this form continued with greater or less distinctness during the opposition of 1887.

Dearborn Observatory, Northwestern University, November 8, 1894.

[FROM NATURE.]

HISTORY OF ENCKE'S COMET.

HISTORICALLY, Encke's comet, which has recently come into view again, stands next in interest to Halley's. The history of the latter can be carried back much farther than that of any other comet. It was indeed conjectured that the one (the first telescopically discovered comet, by Kirch) which made so near an approach to the sun in 1680, and in reference to which Newton first applied his principle of universal gravitation to the motions of these bodies, was identical with comets seen at intervals of about 575 years before, and Gibbon (not exactly an astronomical authority, who recommends others to study Newton and Halley on the question) devotes a section of his forty-third chapter to the supposed history of these early appearances (two of them in mythical times), concluding with the remark that the calculations with regard to it might perhaps in the year 2355 "be verified by the astronomers of some future capital in the Siberian or American wilderness," little thinking how many splendid telescopes would be employed on the study of the heavens in the "far west," before a century had elapsed from his own death.

There was then, in 1794, no observatory on any part of the American continent. But it is now known that the period of the comet of 1680 amounts not only to hundreds, but to thousands of years; and one of the supposed previous appearances that in the reign of the Emperor Justinian was in all probability a return of the smaller or less conspicuous comet which appeared in 1682, and at the next return in 1758–59 acquired the name of Halley's comet, because that eminent astronomer had confidently predicted its return at that date, calling upon posterity to notice that the prediction had been made by an Englishman. He recognized its identity with comets observed in 1531 and 1607, by a comparison of the orbits calculated for each, and considered from the similarity of period that the one comet of 1456 was also probably an earlier appearance of the same. Later investigations, and the accessibility of Chinese records, have shown since his time that successive appearances of this body can be traced with very great probability to a date before the Christian era, our distinguished countryman, Dr. Hind, having taken a leading part in these calculations.

Of the subsequent observations of this comet in 1835, this is not the place to speak, nor of the full expectation astronomers then living will entertain of seeing it again in 1910, and applying the new methods of analysis to it, thereby obtaining information respecting its constitution, which was beyond the wildest flights of imagination at its last appearance. For our present subject is a comet which acquired the name by which it is now universally known as a fitting meed of honor to an astronomer who worthily presided over the then new observatory at Berlin within our own recollection. Many comets have since that time returned according to prediction; but when Encke announced that the small one discovered by Pons at Marseilles on November 26, 1818, was identical with the discovery of Mechain in 1786, of Miss Herschel in 1795, and of Thulis in 1805, no predicted return of any comet but Halley's had ever taken place, though two predictions had been made, by himself and by Bessel respectively, of the returns of comets observed in 1812 and 1815, which duly came to pass in 1883 and 1887, the periods of these being nearly as long as that of Halley's. The remarkable point about Encke's comet was the extreme shortness of its period, amounting only to 1,212 days, or three years and about four months. It was therefore concluded that it would reappear in 1822; true to prediction it did then appear, but from its situation in the heavens was visible only in the southern hemisphere, which then possessed only one observatory, that established (but which has long ceased to exist) by Sir Thomas Brisbane at Paramatta, New South Wales, where the comet was rediscovered by Rumker on June 2. The next appearance took place in the autumn of 1825, when the comet was observed in this hemisphere, and since that time it has never failed to be observed at the calculated epochs. Encke did not desert it after he had determined its period in 1819, but, following up its motions with accuracy, was led to notice a remarkable continuous shortening of the period by a fraction of a day at each return.

The question had before his time been started whether a medium might be diffused through the solar system which, though insufficient to affect the motions of the planets, would produce appreciable effects upon those of comets, composed as they must be of matter in a state of great rarity. Here was a case which seemed to settle the question in the affirmative. Encke's calculations showing that the diminution in the observed length of the period was such as might well be caused by the action of such a resisting medium checking the on ward motion of the comet, which would bring it a little nearer to the sun at each return, and thus shorten both the orbit of revolution and the period of time in which it was accomplished.

The difficulty remained how to explain the fact that no such effect was perceptible in the motions of any other comet; a difficulty which the lapse of time has not removed, for, though in one other case (that of a comet known as Winnecke's) a similar effect was for a while thought to be noticed, further investigation showed that this view could not be sustained. Encke, however, to the end of his life (he died in 1865) was able to trace the above continuous effect in the motion of his own comet, the period of which was then 1,210·2 days, or 1·6 days shorter than it had been in 1819. But, strangely enough, soon afterward, the amount of retardation was reduced by about one-half, at which it has remained from 1868 to the present time. Must the resisting medium theory be modified, or must it be altogether abandoned and some other cause be sought for the retardation in question? Prof. Young suggests a regularly recurring encounter with a cloud of meteoric matter.

When nearest the sun, Encke's comet is at very nearly the same distance from him as the planet Mercury. When farthest from him, it is in the zone of small planets (nearly four hundred of which are now known), revolving between the orbits of Mars and Jupiter. May the attraction of some of these have something to do with the effect above referred to? Small as is the mass of most of the tiny bodies in question, it is possible that at certain times some of them may act together and produce a cumulative and appreciable effect. Of great value to astronomy has been the position of Encke's comet at the other extremity of its orbit, in perihelion. Before its discovery, the mass of Mercury had been rather a matter of conjectural inference than of actual calculation, that planet having no satellite the motions of which would be affected by its attraction.

But at certain returns, the comet of which we are treating made very near approaches to the planet, and the effects produced on these occasions have enabled astronomers to obtain determinations of the mass of the planet as accurate, or nearly so, as those determined for the larger planets which have satellites. The first of these near approaches since the comet's discovery took place in 1835; the last at the most recent return, in 1891.

We now come to the physical appearance of Encke's comet. It has on some occasions, when nearest the earth, been just visible to the naked eye, particularly in the autumns of 1828 and 1848. After Miss Herschel had detected it (supposed to be a new comet), at its return in 1795, her brother, Sir William Herschel, observed it on November 8, and noticed it the following day pass centrally over a star of the twelfth magnitude without obscuring it, whence he concluded that the comet "is evidently nothing but what may be called a collection of vapors." Maskelyne, who observed it at Greenwich a few nights afterward (Bode had in the meantime, in company with an amateur astronomical friend, detected it at Berlin on November 11, four days after Miss Herschel's discovery at Slough), contested this view, on the ground that the nucleus might be situated not in the apparent center of the comet. And this indeed would seem to be the case; the general appearance of the comet, when seen under the most favorable circumstances, being that of a slightly oval vaporous mass, with a small ill-defined nucleus eccentrically situated within the coma. In 1848, toward the end of September, a faint brush of light was noticed by Prof. Bode, extending from the more condensed part of this toward the sun; and a few weeks afterward a tail, between one and two degrees in length, was seen on the other side, i. e., the normal position of a comet's tail.

Late in the month of November, in the same year, it may be remarked, the comet made one of its very near approaches to Mercury, coming within the distance 0·038 of the earth's mean distance from the sun, or about three and a half millions of miles. The return of 1871 was a noteworthy one in several respects; and particularly for the remarkable fan-like appearance which the coma presented in November and December.

The apparent contraction of a comet's bulk as it approaches the sun, and dilatation of it again when receding from him, which has been manifested in several of these bodies, has been especially marked in the case of Encke's, the visible diameter at perihelion being not equal to the twentieth part of what it is about the time when the comet first comes into view. The most probable cause of this would seem to be that suggested by Sir John Herschel, which would make it rather apparent than real, namely, that near the sun a part of the cometary matter becomes invisible by evaporation, just as a cloud of fog might be.

In 1871 the spectrum of this comet was examined by Prof. Young, and found to consist of three bright bands, of which the central one was the most prominent; they were somewhat sharply defined on the least refrangible side, while on the other they were diffused. "Of a continuous spectrum there was no trace, and the spectrum was the same from every part of the comet." But in 1881 a faint continuous spectrum was detected by Prof. Tacchini, so that the result of spectrum analysis applied to this comet would seem to be essentially the same as that obtained from the great majority of comets of which the light has been examined in this way.

At the last appearance of Encke's comet, in 1891, it was first seen by Prof. Barnard at the Lick Observatory in California, at the beginning of August, and passed its perihelion on October 18. At the present return it was detected at the Nice Observatory on October 31, in the constellation Pegasus; and Dr. Max Wolf found it registered on a photographic plate taken by him the same evening at Heidelberg. As on several previous occasions, its ephemeris has been calculated by Dr. Backlund, of Pulkowa; and it is matter of regret to notice his accompanying announcement that this is the last occasion on which he will be able to undertake it.

W. T. LYNN.

THE CHAMELEON—A QUEER REPTILE.

By S. L. CLAYES.

THE chameleon is one of those many creatures around which curious traditions and fables have delighted to cluster. A power of changing its color to harmonize with that of the object upon which it rests and the habit of feeding upon air alone have been credited to it from the earliest times. While the first of these attributes is now accepted as a well-authenticated fact, investigation has proved the last to be wholly fabulous. As late, however, as the earlier half of the eighteenth century Frederik Hasselquist, a Swedish naturalist of some note, seriously considers its probability. After observing the chameleon in the neighborhood of Smyrna, and again in Egypt, he gravely narrates that the inhabitants told him "it would assume the color of a piece of cloth or other painted or colored substance which might be put before it. Some assured him it lived only on air, but others told him that they had seen it catching a sort of very small flies."

Our naturalist has this of excuse for the seriousness with which he received the folk lore: he might possibly have observed the creature long and carefully without disproving the mistaken assumption, for, while it must eat sometimes, a chameleon has a wonderful power of abstemiousness and may live for a considerable time, weeks perhaps, in apparently perfect health without once breaking its fast. Finally, however, Hasselquist was convinced that it ate more than air, for in the stomach of one which he dissected he found the remains of several different insects, tipulæ, coccinella and butterflies. He was not equally fortunate, it seems, in discovering the truth in regard to its changes of color, which he failed to verify, although he kept one for a long time and was persistent in his experiments.

Often as he tried, he could never see that it assumed "the color of the objects presented to its view—flowers, cloth or paintings." Although he records that under certain conditions it would change from its natural hue of iron-gray to a sort of brimstone yellow—sometimes to a darker yellow, approaching a green—he found these changes were induced rather by the hot rays of the sun or some irritation of temper on the part of the reptile than by any suggestion of color in its entourage.

Chameleons are natives of the hotter regions of the old world. They are found in Asia, but are more abundant in Africa, while Europe has but a single species, which is confined to some of its most southern parts, as the vicinity of Cadiz. Many have been carried farther north for scientific purposes, or as curious pets, but they seldom long survive the change to a more austere climate.

Chameleons form a distinct family among the saurian reptiles. While far from possessing beauty or grace, they are, from their marked peculiarities of form and structure, highly interesting to the naturalist. The body is much compressed, being very deep and narrow; the dorsal line is sharp, and in some species rises fairly into a crest or hump. The head is very large. The neck is so deficient as to seem absolutely wanting, and the head to spring directly from the shoulders; in fact, it is so short as to preclude the possibility of turning the head, which remains fixed in its position, moving only as the body moves. In compensation for this immobility, the eyes, which are large and extremely prominent, have an unusual power of motion in every direction, and, curiously enough, each eye also moves separately and independently of its fellow, the two commonly appearing to be fixed in interested attention on totally different objects. Thus one eye may be directed upward and backward, while the other gazes at something beneath, giving to the creature a most peculiarly uncanny and ludicrous air. "But," an old writer observes, "what is most extraordinary in this motion is to see one of the eyes move while the other remains immovable; the one to turn forward at the same time the other looketh behind; the one to look up at the sky when the other is fixed on the ground."

The entire ball of this strange eye is covered by a skin or membrane in lieu of an eyebrow, which, closely attached to the eyeball, moves as it moves, and is pierced by a hole only just large enough to permit the pupil to peep through, giving it the look of a living gem in a shagreen setting. The large head is raised at its back part into a sort of cone-like crest, which is carried forward in a ridged arch overhanging the orbit of each eye. There are no external ears, the internal organ of hearing, while present, being entirely concealed. The mouth, like that of most reptiles, is wide and is filled with teeth, which are small and sharp,

but superficial, having no depth of roots. The legs are longer than those of other saurians, thus raising the body higher than is usual with these reptiles. The feet are like those of the parrot in their structure, having each five toes divided into two opposing sets, one of which turns forward, the other backward, giving the creature the same power of grasping as if it were possessed of four hands. The toes are bound together to their last joint, and each is armed with a sharp claw. The tail is long, round, tapering like that of a rat, and prehensile, being quite as capable of grasping as are the clever feet. The skin, while not covered with scales, as is that of many saurians, is deeply roughened with horny granules, its texture forcibly reminding one of shagreen. The tongue of the chameleon is a peculiar and most interesting organ, especially adapted to the capture of the insects, slugs and such other creatures as form its food. Like those of the humming bird and woodpecker, the tongue is vermiform and erectile. It consists of a long and extremely extensile tube, quite hollow with the exception of its tip, which is composed of a solid, fleshy tubercle. When drawn into the throat it folds upon itself somewhat in the same manner that a small telescope does when closed.

This tube, bathed in a viscous saliva, is darted forth and retracted with lightning speed by the animal, striking with absolutely unerring aim the object of his desire, which adheres to its clammy surface and is carried by it into the mouth. As it measures quite the length of the chameleon's body when fully thrust out, this wonderful tongue is capable of seizing upon its prey when it is moving at a seemingly impossible distance away. One acute observer says: "I never knew a chameleon I long kept to miss his aim but once, and then the fly was on the other side of the glass. An insect on a leaf at an apparently hopeless distance, or a drop of water on a twig, is gone so instantaneously that the spectator is astonished." Another tells us that "when two mealworms were placed before a chameleon, one on one side and one on the other, at different distances, the eye of each side was leveled at the adjacent insect; and though the eyes were necessarily looking in different directions, the tongue did its duty upon both, one after the other, when they came within reach."

But while the tongue and eyes are swift as light in their motion, the chameleon itself is slow and torpid. It is arborescent in habit, and once planted upon a tree and fixed firmly to its moorings by the tenacious grasp of its hand-like feet and prehensile tail, it will remain, but for its eyes and tongue, immovable for hours.

Although far from subsisting upon air alone, the chameleon is capable of enduring long fasts; and a century or more ago observers were prone to test to the bitter end the poor reptile's powers of endurance in this respect. Hasselquist kept a chameleon alive from the eighth of March till the first of April, without allowing it any opportunity to feed. "Notwithstanding its fast," says its biographer, "it was nimble and lively during the greater part of the time, climbing up and down the bars of its cage, fond of being near the light, and constantly rolling its eyes." Finally, although Hasselquist, seeing it gradually grow thin and weak, became convinced it was suffering from hunger, he remained inflexible, and the poor reptile, at last, through weakness, lost its hold upon the bars of its cage, and falling, was injured and soon after died. Le Bruyn declares that the chameleons which he kept in his apartment at Smyrna lived upon air; but naively adds that in a short time they died one after another. At Alexandria, Sonnini took every precaution to prevent those which he had in captivity from obtaining other food while exposing them freely to the air. Under these conditions they lived about twenty days, but soon lost their plumpness and vivacity; their colors went as their strength decreased; their skins became livid and wrinkled, their condition deplorable. To quote his own words, "they had the appearance of being dried before they ceased to exist." The chameleon possesses lungs of unusual size, which are connected with air cells lying among the muscles and just beneath the skin. These give it a remarkable power of inflating itself, which, with its peculiar habit of gulping air in respiration, may have first suggested to the ancients the thought that it subsisted upon air alone.

The curious power of changing color appears to be partially under the control of the volition of the animal; it seems also to depend in some measure upon the action of light, while we have the most convincing proof that it is influenced by fear and other passions of the creature. Milne Edwards discovered the existence of two layers of pigment in the skin, one gray and the other of a violet hue, so arranged as to be blended together, while sometimes one of these entirely conceals the other. Their action is still somewhat of a mystery. Professor Owen remarks that "the nature of these layers, when fully understood, may be expected to elucidate the mysterious operations of light in producing and affecting the color of animals.

Dr. Weissenborn states that in his opinion the two lateral halves of the chameleon are somewhat more independent of each other, and are not united in a whole as homogeneous as they are in the case of most other animals. He says: "Many circumstances favor the opinion that the nervous centers in one lateral half are going on independently of those in the other, and that the animal has two lateral sources of perception, sensation and motion, besides the common one which must reside in the faculty of concentration. When the animal is agitated, its movements appear like those of two animals glued together. Each half wishes to move its own way, and there is no concordance of action. The chameleon, therefore, is not able to swim like other animals; it is so frightened, if put in the water, that the faculty of concentration is lost, and it tumbles about as if in a state of intoxication. The chameleon, moreover, may be asleep on one side and awake on the other." On approaching it at night with a candle, "the eye turned toward the flame would open and begin to move, and the corresponding side to change color; whereas the other side would remain for several seconds longer in its torpid and unchangeable state, with its eye shut."

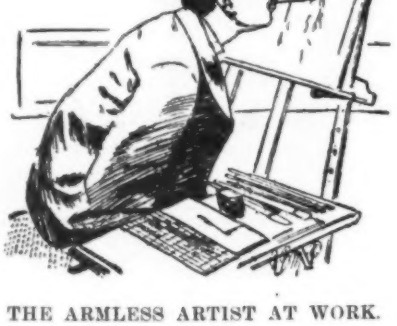
To the physicians of ancient times the chameleon must have been a veritable treasure house of remedies. "Take the ashes," says Democritus, "of the left thigh or foot, chuse you whether, incorporate the same with the milke of a sow, and therewith annoint the feet; it wil be an occasion speedily to bring the gout upon them." On the other hand, Trallianus prepared from it a medicine most certain for driving the gout away. Moreover—"of the chamæleon's gall, for the most part, folk are in manner verily persuaded, that it will rid the pin and web, the cataract also of the eies, with three dais' annointing: chase away serpents if it be dropped in the fire; gather all wezils in a country together, only by throwing it into the water; and fetch off the haire if the body be annointed therewith."

But while the nucleus of so many imaginative tales, we find the chameleon to be, in point of fact, only a weird, homely, harmless creature, clinging to his branch, and asking for but a tiny insect, now and again, to sate his appetite and make him happy.—Popular Science News.

AN ARMLESS ARTIST.

IN a little gallery at 175 Piccadilly, London, a most interesting exhibition of paintings, sketches, and decorative designs is now to be seen. The paintings, which include sea and landscapes and figure subjects, are marked in many cases by a high degree of finish, while the decorative designs, which include panels, friezes, finger plates, and fans, are really remarkable for taste, effectiveness and originality; and, incredible as it may seem, all these are the work of a young artist who lost both his arms when a child, a tramcar accident having necessitated a double amputation.

"I was eight years old when I met with my accident," said Mr. Bartram Hiles to two representatives of the Daily Graphic—artist and penman—who visited him among his pictures recently, "and I was still a boy when I first began to amuse myself by painting and drawing, holding the brush or pencil with my teeth. I exhibited my first picture at the Bristol Academy when I was sixteen years of age, and it found a purchaser. I was at that time studying at the Technical College, at Bristol, with the view of competing for a scholarship at the National Art Training School. I succeeded in winning the national scholarship of the value of a hundred pounds for two years; and while I was at South Kensington I won in national competitions one silver medal, two bronze medals, and a book prize for design. I left the training school in 1892, and went to Paris for a short time to study art



THE ARMLESS ARTIST AT WORK.

there. Last Christmas I held an exhibition of water colors at Bristol, and it proved very successful, as out of thirty drawings I sold twenty-seven, one of them being bought by the Princess of Wales. That is about all I can tell you about my career as an artist up to the present."

"Don't you find it very difficult to mix the colors?" asked the Daily Graphic artist.

"I don't find any difficulty whatever," replied Mr. Hiles. "I can mix them just as easily as if I had hands. I sometimes work on a flat table, but I do a good deal of work at the easel too. I might mention, too, that I have taken a first class certificate for modeling."

"For modeling! How do you manage that?"

"Well, when the clay is brought to me I beat it up with my chin, and then take it abroad with my lips. I then place it on the slab, and finally put the finishing touches with the modeling tools held in my mouth."

"Don't you find that very difficult work?"

"It is not so difficult as it is unpleasant. Modeling in clay with chin and lips is not agreeable work. I do not carry it on now. I did it simply in order to gain the certificate which you may see hanging on the wall there. I may add that I have had a work accepted and hung at the Royal Society of British Artists, and this year, I also had a work accepted but not hung, at the Royal Academy."

Just then a party of intending picture buyers claimed Mr. Hiles' attention, and his interviewers took leave of him. His exhibition is one which not only well repays a visit by its intrinsic merit, but which especially deserves encouragement as an example of what may be done in the pursuit of art against the almost insuperable difficulties imposed by a terrible affliction.

THE NEW STAMPS.

THE new issue of postage stamps will differ from the current issue in several particulars. Its denominations, for example, will be one, two, three, four, five, six, seven, eight, ten, fifteen and fifty cents, and one, two and five dollars. The regular current issue—that of 1890—has no eight-cent stamp, for that became necessary only with the change in the registry fee from ten to eight cents during the late Postmaster-General's administration. Neither has the issue of 1890 any fifty-cent stamp, or any of the series from one dollar upward. The coming issue will drop out the thirty and the ninety-cent stamps, transferring the heads of Thomas Jefferson and Commodore Perry, which now stand on them, respectively to the fifty-cent and one dollar denominations. The Postmaster-General has made the designs of the two-dollar and five-dollar stamps a special consideration. Looking over the rest of the series he found portraits of Washington, Jefferson, Franklin, Jackson, Lincoln, Grant and Garfield, representing the executive branch of the civil government; Sherman representing the army, and Perry the navy, and Webster and Clay representing the legislative branch. But the judicial branch has been persistently ignored in the stamp portraits from the foundation of the government till now. In an earlier issue Alexander Hamilton had figured, but the great constitution maker of opposite education and faith had been ignored, so now John Marshall and James Madison are to appear on the two-dollar and five-dollar stamps.

SILURIAN CARBON.

By W. R. MACDERMOTT, M.B.T.C.D.

FROM time to time a vast amount of money has been wasted in the north of Ireland and elsewhere in Britain in searching for coal in the Silurian. At Tullygarvan, near Saintfield, in the County Down, at Coalpit Bay, in the same county, at several points in Armagh and Cavan, one may come across deserted shafts, the traces of the futile quest. Among the peasants a common notion is that there is plenty of coal in the country, but that the "government" does not let it be worked. In truth, the evidence of carbon in the Lower Silurian in anthracitous shales, seams of lignite and disseminated graphite, and the striking resemblance the formation bears physically to the common form of the productive coal measures is so plain that though, of course, no workable coal fields exist, it is yet highly probable that the formation is to a great extent made up of their wasted and worn-out remains, of what coal fields come to in their last stage.

The life forms of the Lower Silurian, as known up to date, are so purely marine, so oceanic, indeed, that a marine origin is assigned to its carbon in books. As, however, a physical fact and a fact of geology in the known range of observation, masses of black carbon equate themselves to broad sunshine land surfaces and terrestrial vegetation. It would contradict our physical knowledge to suppose that such masses could be formed in the darkness of ocean bottoms, and no fact of observation, geological or otherwise, calls for the contradiction.

The Silurian carbon cannot be accounted for on the base of its now observable extent. Even so it could not be accounted for under any theory of marine origin, but just because it is carbon under a vast experience of condition, it must be looked on as a mere remnant and trace of its original development. The chemical nature of carbon is such that it cannot survive indefinitely the inevitable experience of time. We see this in the true Carboniferous itself. In the geological perspective, the coal fields of Eastern Pennsylvania are but the broken, wasted, and much altered remnant of an ancient development. To bring the Silurian carbon into geological perspective, we have to conceive the experience of condition of the Eastern Pennsylvania Carboniferous vastly extended, and think, then, how it would appear to us. If we do so, we shall have reason to think that we have in the Silurian not the occasional preservation of a few thin beds of marine vegetable origin, but remains indicating a mass of terrestrial plant life greater even than that of the Carboniferous.

In the general case, carbon is incapable chemically of lengthened preservation. Forests and morasses, undisturbed and unprotected, waste away as if burned. A section of an Irish bog shows what masses of vegetable matter come to as a rule; the base of the mass is a layer equivalent to ash, and ultimately the whole would naturally resolve into such stuff; this, and not coal, represents the general fate of vegetable carbon. We have no right, therefore, to infer from the absence of fossil carbon the non-existence of land surfaces clothed with vegetation.

The geological indications of average land surfaces must, in fact, be extremely imperfect and scanty, and, of course, the more so as we go back in the record. Here in this Silurian area the modern land surface, so important in its record of a life all its own, is but a thin layer of soil, friable and incoherent. Even as it is the characters of its base—marine of course—predominate over all that is modern in it. Placed edgewise to the sea, into which it is thought at some points to be sinking, it is slowly worn away along with the solid rock on which it rests. Its contribution to the resultant debris is thus almost infinitesimal and, such as it is, from its friable nature, widely diffused and lost. Now this gives us, in plain terms, before our eyes, the general character of land surfaces. This surface before us would be easily and almost immediately and completely effaced by submergence in the sea, and the average land surface in all past time must have been of the same kind and liable to the same fate. The marine predominance so marked in the geological record is really due to the fact that the great sea function has ever been the building up of solid masses of rock, capable of enduring for ages, while the land function has been the formation of thin, friable layers of soil, readily and quickly capable of being obliterated with all they contain.

In the great carbon deposits we have true rock masses, true rock formations of terrestrial matter, but we owe their preservation to marine and fluviatile agency. Land surfaces and plant life we might have had in luxuriant abundance, but without the exceptional water agency seen in the coal measures we would have but faint traces of them left. What traces of the average upland surfaces which must have existed in the Carboniferous period have we left? We know just as much of the average land surfaces of the Carboniferous as we do of the Silurian; in both cases we have only indirect evidence, necessarily faintest in the last. The evidence we have is evidence of peculiar local vegetation preserved under exceptional circumstances; we have little or nothing to testify to land surfaces in the ordinary acceptation. But it is more reasonable to think that they were incapable of preservation than that they did not exist.

If vegetable carbon in the general case is oxidized and lost, this must be true of it to some extent, even under the most favorable conditions for preservation.

Coal oxidizes as well as peat in presence of air and water, though, of course, much more slowly. It has to reckon not only with the chapter of accidents, or rather with the inevitable incidents of time, but with a constant, definite operation of interstitial waste. In the coal measures we have not only coal, but what was once coal, just as the base in peat was once peat. We have no right to think that a coal field, even if not broken up and denuded, would last in the same form forever; we find signs of interstitial waste and contraction in all coal deposits. Now, not only do such deposits, as a rule, teem with marine remains, but these are in better preservation and in a better position for preservation than the land remains, which go more purely with the coal. The ultimate form the coal formation would, therefore, assume in the course of time would be one in which the marine element would greatly and clearly predominate, as it does in the Silurian.

But though carbon, whether as peat or coal, ultimately wastes away, as lignite and anthracite it is more permanent, and much more so as amorphous and crystalline graphite. The mode of formation of the graphites is extremely obscure, but their association with the Palæozoic coals seems pretty constant. In common with anthracite, anthracitous shales and mineralized lignites, associated with pyrites and other minerals, just as in the coal measures, they point as residua to original vast carbon deposits with the implication of corresponding land life. The carbon trace in these forms is so widely diffused and characteristically marked in the older Palæozoic that, taking into account the age of the series, it would be a bold thing to deny that residual character. It would land us, through ignoring observed effects of the flow of time, in the difficulty of accounting for the old carbon trace with no physical data to go on.

It has, perhaps, too easily passed into a canon in geology and biology that marine predominance, increasing with age, is a fact of existence. It is, no doubt, a fact of observation, but its real nature as such is sufficiently plain to prevent error. Not only does sea vastly predominate over land, but the base in land is everywhere predominantly marine and, as rock, enduring as friable land cannot. From first to last the extreme tenuity and destructibility of the land layer must be borne in mind in interpreting the geological record. Its mass and durability is out of all proportion less than its importance in the chapter of life; in geology it is, as it were, a thing of cloud and mist. Its contribution to the geological deposits must always have been relatively scanty, fragmentary, and imperfect, and, therefore, more liable to vanish under the lengthened experiences of condition. In the Lower Silurian, from the denudation of which the overlying formations were built up, the significance of land indications is inversely, not directly as their manifestation. The ghosts of coal which tempted us here to mine Llandeilo beds, in which even marine fossils are probably preserved only because "done in carbontype," fossilized in graphite, are really more significant than the actual coal of the Carboniferous. For as this Silurian, compared with the Carboniferous, is itself but a basal remnant, a worn and wasted relic, the evidence of vegetable life in it read out into so much the larger characters. The trace here cannot really, I believe, be thought obscure or doubtful, but the faintest trace, if certain, would imply a development of land life totally at variance with current ideas in geology.

Poyntz Pass, Newry, Ireland, October 15, 1894.

ECHINOPSIS DECAISNEANA.

THIS is one of about thirty species which constitute the genus Echinopsis of some botanists, but which is regarded only as a subgenus of Cereus by others. They possess a good distinctive character in their short, more or less spheroid stems, regular angles, short tufts of spines and in the exceptional length of their flower tube. The species figured is a good example of the whole. Out of flower an Echinopsis may be likened to a melon ridged longitudinally, painted green, with little bosses of spines and wool stuck at regular intervals along the ridges—a plant of totally unattractive aspect. But in flower it is "a horse of another color." Each flower is six inches across, of the most delicate satiny texture, white, creamy-yellow, yellow, rose, or rosy-red, and deliciously fragrant. In the species here figured the flowers are white. They last only about two days, just long enough to make one appreciate them. I quote what Dr. Lindley said of one of the best known species, viz., E. Eyriesii: "Independently of the large size of the flowers, they are remarkable for the rich delicate odor they exhale at night, at which time the glorious blossoms expand. When young, they resemble long sooty-gray horns, covered over with a thick, shaggy hairiness, and would never be suspected to conceal a form of the utmost beauty and a clear and delicate complexion. When the hour of perfection has arrived and the coarse veil of hair begins to be withdrawn by the expansion of the unfolding petals, one is amazed at the unexpected loveliness which stands revealed in the form of this vegetable star, whose rays are of the softest white."

I do not know any plant which will produce such a large display of blossom in proportion to its size as these Echinopsis will do under suitable conditions. The plant represented in the figure was grown by Mr. Shane, of Vancouver. Growers of cacti will agree with me that it is scarcely possible for such a specimen to be cultivated in this country. If we could flower cacti freely, there is little doubt that they would soon become favorites, as the two genera that do flower freely with us, viz., Epiphyllum and Phyllocactus, are already.

I know a good collection of Echinopsis which rarely produce blooms. They flowered better last year than usual, but then the summer was a record one. Possibly better results are obtainable by some special kind of treatment than we have got to yet. I read last year an account of some plants of Echinopsis grown in the town of Grimsby which flowered exceptionally well, and which were grown planted out in the open air from June to October, then lifted and kept in boxes in a room and kept dry, well aired and in a good light till planting out time came round again. Ten degrees of frost did not hurt them when they were dry. This treatment is simple enough, and the results, as recorded, are far better than anything I have ever seen done under pot culture. We planted a set of ours out this year, and they have grown very well, and if they flower freely next year after such a sunless summer as we have had, then the Grimsby method will be a big step forward. Probably we coddle our cacti a great deal more than is good for them. Mr. Cannell and Messrs. Carter & Co. are almost the only English nurserymen who deal in cacti; but in France, Germany and the United States there are many nurseries devoted to them. In the catalogues of two French nurserymen, viz., MM. C. Simon and P. Rebut, I find over thirty species of Echinopsis alone offered. Lovers of such plants please take note.—W. W., Kew, in the Gardeners' Chronicle.

[Continued from SUPPLEMENT, No. 990, page 15828.]

ELECTRICITY AND PLANT GROWING.*

By L. H. BAILEY, Professor of Horticulture, Cornell University, Ithaca, N. Y.

THE influence of this naked light upon productiveness and color of flowers was found to vary with the different species, and different colors within the same species. Several named varieties of tulips gave interesting results. When these came into full flower, it was found that in every case the colors were deeper and richer in the light house; but the colors lost their intensity after four or five days, and were then indistinguishable from those in the dark house. The plants in the light compartment had longer stems and larger leaves than the others; and there was a greater number of floriferous plants in the light. These tulips were grown at distances of ten and twelve feet from the lamp. Petunias were much affected by the light. The plants were much taller and slenderer in the light, even at the farthest corners of the house twenty and thirty feet from the lamp, and they bloomed earlier and more profusely. When the specimens were in full bloom, it was found that the height of plants in the dark house was to the height of those in the light house as five is to six. White petunias were not changed in color by the light, but purple ones quickly became blue, especially near the lamp.

Other flowers behaved differently, each according to its kind; but all those, of whatever species, which stood within five or six feet of the naked arc were

ECHINOPSIS DECAISNEANA.

injured. Flowers opening near the light were of short duration, but those ten or twelve and more feet away did not appear to be modified in this regard. But it was apparent that, in general, the light hastened blooming and caused the production of longer stems, but this effect was much obscured by the injuries resulting from the unscreened arc. Subsequently we have found that the use of a globe or pane of glass will avert the injuries to flowers as well as to foliage, and the long stems and open inflorescence, together with increase in earliness in some cases, may be obtained without fear of injury. Yet we are not ready to recommend the electric arc lamp for the growing of flowers.

If the noxious effects of the electric light can be overcome by the interposition of glass, it remained to determine whether the light can be hung above the house to advantage, the glass roof serving as the screen. A lamp, surrounded by a globe, was hung six feet above the middle of a glass roof, and lettuce, endive, beets, radishes, and spinach, and other plants, were grown beneath. The lamp was so arranged that half the house had no electric light, while the other half received the full glare of the arc. The lettuce, as usual, was from a week to ten days earlier in the lighted compartment, and the effect was marked in the remotest corner of the house, forty feet from the lamp. Endive, which has been injured in other experiments, now showed no bad results, although it did not appear to be benefited; but radishes, which had been among the plants most seriously injured in all our experiments, now showed for the first time a decided gain in the light compartment, indicating that at a certain degree of attenuation the light may be made acceptable to any plant. The plants in the light house were ahead in every feature. The proportion of tops to the entire plant was greater in the light than in the dark house, the difference being that between 55 per cent. and 49 per cent. In 1890, under the naked light, radishes were uniformly injured, the loss ranging from 45 to 65 per cent.; the same year, under a light protected by an opal globe, the injury was still apparent, but the loss in tubers was only from one to five per cent. of the crop, but at the same time the weight of leaves was increased; now this year, under light strained through a globe and a glass roof, there was an increase in both tubers and tops. Similar results were obtained with beets and spinach; but cauliflowers were decidedly better in the dark house, thus adding a new source of perplexity, the discussion of which will be resumed presently.

Violets and daisies were also grown in this experiment. In both instances, strong plants were set in the beds a few days before the light started. The violets (Marie Louise) were all set in the light house at twelve to sixteen feet from the lamp, where they received the full benefit of the light. Half of the bed of one hundred plants was covered each night with a black enamel cloth box, provision being made for ventilation, and the other half received the light. Three weeks after the light started, the exposed plants began to bloom, while no buds could be found in the darkened portion. It was not until five weeks after the starting of the light that a flower appeared in the darkened plants, while the others had continued to bloom. Fifty strong plants of the low daisy (Bellis perennis) were divided between the two houses. Those in the light compartment were from fifteen to eighteen feet from the lamp, in rather weak light. The first bloom appeared just four weeks after the starting of the light, and it was in the light house. For a month or six weeks thereafter the lighted plants bloomed more profusely; but at that time the dark house plants began to surpass the others, both in numbers and size of flowers and vigor of plants. In other words, the lighted plants bloomed earlier and never made such stocky plants, and they soon exhausted themselves. It is probable that they would have endured longer if they had been established in the beds for a longer period before the light was put upon them.

In addition to all these plants, we have exposed many other plants to the influence of the arc light with varying and interesting results. Of these, the most obstinate appear to be cucumbers, tomatoes, and beans, none of which we have been able to persuade to cast off the ways of their fathers; but we are still hopeful that they may respond to the attractions of the higher education!

I have already referred to the poor performance of cauliflowers under the light; and this introduces a subject which I have only hinted at heretofore—the fact that the electric light often changes the habit or method of growth of the plant. The light makes cauliflowers grow tall, and draws the leaves up to a nearly vertical direction; while plants in a normal house or far removed from the light are lower and spread their leaves, at maturity, nearly horizontally. Plants near the light are also lighter green than others, and, contrary to other experience, they seem to be somewhat later in heading. The difference in stature of plants at distances of ten and fifty feet from the lamp was very marked, the average heights at these respective points being as five is to three. The plants at the remote end of the rows, although lower and weighing only about four-fifths as much as those near the lamp, produced earlier heads. In other words, the light seemed to produce leaf and stem growth at the expense of heads; and this rapid growth of the strongly lighted plants was further shown by the much more brittle and tender tissue of these plants.

Most plants show a similar modification of habit under the immediate influence of the light. As a rule they grow taller. The tallness is ordinarily due to a longer growth, but it is sometimes only the result of erectness. Thus on the seventh of last month, I secured two pots of oxalis, each containing two plants of equal size, and placed one pot eight feet from the lamp and the other forty-five feet from it in diffused light; at the same time I took two equal pots containing one plant each and set them in the same positions. Three weeks later there was a marked difference in the two lots, those nearest the light being considerably taller than the others; yet these tall plants appeared to have made no more growth than the others, for the total growth of one pot in the light was to the corresponding pot in comparative darkness as 58 is to 74, while in the other the ratio was reversed, being as 43 is to 33. This taller growth was probably a species of heliotropism or growing toward the light, for the artificial light proceeds from a definite point overhead, while the sunlight is much diffused.

In contrast to this behavior of the oxalis, however, may be cited the case of three equal primula plants without flower buds, which were selected for experiment the first of January. These were placed together twelve feet from the naked arc. One plant was unprotected, one was screened by a pane of window glass, and the third was covered at night so that it stood in darkness. Four weeks later the plants were in flower, with little difference in the earliness of the first blossoms, although the plant screened by the pane was producing more buds than either of the others; but the plant kept in darkness was much shorter than the other two, for while each of them stood five and one half inches high, this was only three and three-fourths inches.

It is important that we notice the fact in this interesting behavior of the primulas, that the fully exposed and the glass-screened plants seemed to be equal in every respect; in other words, the baneful influence upon primulas of the electric arc light of 2,000 candle power does not extend twelve feet. This leads me to say, what you have already inferred from this discussion, that the injurious effect of the light ceased at certain distances, but that these distances vary for each species of plant. As a rule, there is little injury beyond ten feet, although certain coleus plants standing fifteen and more feet from the lamp are injured.

This leads me to ask just what these injurious effects are. It is now pretty definitely ascertained that they are due to the highly refrangible or ultra-violet rays of the spectrum; and these rays are mostly absorbed by plain glass. Plants set near the naked light soon show a browning of the leaves and fresh stems, and in some instances the tissues may be killed. But if a pane of glass is interposed before half the plant, the protected portion will be very little if at all injured; and the projecting leaves will usually show the exact line of demarkation between the screened and unscreened fields. The character of this injury may be learned from the following narrative. On the seventh of last December, a strong heliotrope, which had two equal shoots springing from near the base, was placed about three feet from a naked arc of 2,000 candle power. One shoot was screened by a pane of third quality single-thick window glass placed directly in front of it, while the other branch was fully exposed. Neither branch had made flower buds. The next morning, the

* From the transactions of the Massachusetts Horticultural Society.

light having run six hours during the night, both branches were strongly bent toward the lamp, and the exposed one, as well as the portions of the leaves of the other shoot which projected beyond the pane, showed a distinct brown discoloration. After three nights had passed, the exposed foliage began to curl, but the protected portion was pushing forward very rapidly and had already made good flower buds, while the other showed only the faintest traces of buds. After ten days, the exposed portions were much browned and stunted, and the small flower buds which had been formed appeared to be dead. On the seventh of January, just a month after it was placed before the lamp, the screened branch was in full and normal flower, while the other was little more than half as high, most of the leaves had fallen and the remaining ones were small, curled, and dry, and the few almost lifeless flower buds were unable to open. Other heliotrope plants set six feet from the arc showed trifling injury five or six days thereafter, but the exposed parts flourished and bloomed several days earlier than branches behind a pane, and the flowers were in every way normal. Two branches which were of equal length when the experiment began were thirteen and eighteen inches tall at the expiration of six weeks, the shorter and earlier portion being that which was fully exposed. It was therefore evident that while the naked arc is fatal to heliotrope at a distance of three feet, it is not injurious and it accelerates maturity at six feet. Coleus plants have proved to be most interesting subjects for experiment. The purple color of some leaves entirely bleached out in a few hours if exposed within a few feet of the naked arc, while those portions of the same leaves behind a pane of glass remain uninjured; and the line of demarkation between the two portions will often be as marked as if it were the impression upon a photographic plate.

It now remains to determine the nature of this injury. If a cross section is made of an injured leaf of heliotrope, it will be found that the epidermal cells have collapsed—the walls have fallen together; and as these dead walls become opaque, they obscure or cover up the bright chlorophyl beneath and make the leaf brown. The chlorophyl bodies themselves may be disorganized, although this result follows only as a secondary phenomenon. A careful study of many plants treated to the electric light has enabled my colleague, Professor Rowlee, to ascertain the physiological effect of the injurious light. The ultra-violet rays produce great activity in the protoplasmic contents of the cells, particularly of the palisade tissue, or hasten the physiological processes. This activity calls at once for large supplies of water, and it is drawn first from the overlying epidermal cells; and these cells being emptied of their contents, collapse like an empty grain bag. The loose mesophyl or underlying portion of the leaf is abundantly supplied with moist air in the large intercellular spaces, and it is also in direct communication with the moisture of the atmosphere through the stomata; so the lower tissue is much less injured by the sudden withdrawal of water than the upper layer. In other words, vital activity is hastened so much by the naked light that the plant cannot supply materials quickly enough, and it is forced to death; but by removing the plant to greater distances from the lamp, a point will be found where water can be supplied with sufficient rapidity to meet the demands of the quickened activities, and the plant will grow more rapidly or at least mature earlier than in normal conditions.

In the coleus leaf, however, there are two somewhat distinct effects of the naked light which obscure each other. The leaf is injured by the process described above, and it may also lose its color. We soon found that some varieties of coleus are not bleached, but the upper epidermis simply becomes glossy by exposure to the naked light. Microscopic examination shows that those specimens which lose their color hold the color pigment in the upper epidermis alone, and that it is extracted by the collapse of the epidermal cells, and the chlorophyl of the interior cells is exposed, causing the leaf to become greenish. Iresine (or Achyranthes) is one of those colored plants which hold the coloring matter in the interior of the leaf, and it is not bleached by the electric light. Knowing these facts, we are able to prognosticate with some certainty what plants will be injured in color by the arc light, for those which have the color distributed through the tissue and which are, therefore, not discolored, are, normally, nearly or quite as deepiy colored on the under side of the leaf as on the upper side.

If the electric light exerts such profound effects upon the physiological processes of plants, we need not be surprised if it produces anatomical modifications. Bonnier is the only person who has investigated this subject. His experiments were directed to both trees and herbs grown under the influence of electric light run continuously with little aid from the sun, and the same light run for a part of the day only.

His conclusions as to the behavior of trees are as follows:

"1. We can produce by a continuous electric light, considerable modifications in structure of the leaves and young stems of trees.

"2. We can produce a condition in which the plant respires, assimilates, and transpires both day and night in an invariable manner. The plant then seems to be so much affected by this continuous light that the tissues take on a more simple structure.

"3. The intermittent electric light (twelve hours of darkness in the twenty-four) produces in the various organs a structure which approaches more nearly the normal structure than that produced by the continuous light."

His conclusions upon the structure of herbaceous plants are these:

"1. When the continuous electric light, under glass, produces in an herbaceous plant a large growth, with intense green color, the structure of the organs is at first much modified or differentiated; but if the light is intense, and continued during several months, without check or diminution, the new organs formed by the plants which adapt themselves to this light present remarkable modifications of structure in their various tissues, and are less differentiated, while at the same time being rich in chlorophyl.

"2. The direct electric light is injurious to the normal development of tissue because of the ultra-violet rays, even at a distance of three meters and more from the lamp."

There remains one point to which I must call your attention: When do the lighted plants grow? It is known that growth is ordinarily more rapid at night. But when the sun supplies light by day and the arc lamp supplies it by night, at what time will the plant choose to perform this function? It is probable that most plants will grow more or less continuously, but more rapidly under the electric light. In fact, we have found that a petunia plant which was subjected to normal daylight, then to electric light until 11 o'clock at night, and to normal darkness from that hour until morning, grew most rapidly when the electric light was burning. Careful tests with lettuce gave the following conclusions: 1. That the electric light did not determine the periodicity of growth. 2. That increase of growth under the light occurred only during the first days of the experiment. 3. That growth in both the light and dark houses took place in daylight as well as in darkness.

I may now say, in conclusion, that the electric arc light exerts a powerful influence upon plants in greenhouses, and that all species, and sometimes even garden varieties, are affected differently. This varying influence is the effort of the plant to adapt itself to the new conditions in which it is placed, and the modification undoubtedly bears some relation to the elasticity or fixedness of the organization of the plant, and, therefore, to the conditions under which the species has been evolved. And it must, therefore, follow that if plants were to be subjected to the electric light through several or many generations, more or less adaptive varieties would arise, in the same manner in which plants have adapted themselves by profound variation to the requirements of greenhouse cultivation. The electric light affects plants by hastening growth or maturity; but this effect may be so powerful as to destroy the plant. The injury is avoided, however, by screening the light through a glass or by removing the plant to such distance that the mischievous effect of the ultra violet rays is dissipated. I consider it to be established that lettuce can be profitably aided by the electric light, and it is probable that many flowers can be similarly benefited. Beyond this I can only say that the fundamental principles involved are now pretty clearly understood, and that the near future should give us results of direct economic value.

II. The Application of Electricity, or Electric Currents, to Plant Growing.—There have been many attempts to determine the effects of electrical currents or electrification upon growing plants. The initial experiment was made by Maimbray in Edinburgh, so long ago as 1746. He submitted two myrtle trees to the influence of electricity, and found that their flowering was much hastened. A number of experiments followed at intervals, but the results were various and contradictory, and few conclusions can be drawn from them, until Grandeau approached the subject in 1878. It will be useful to take a very brief survey of these experiments, although I cannot discuss them so confidently as I have the influences of electric light upon vegetation, inasmuch as I have made no experiments in this direction myself. But the general trend of the subject may, perhaps, be determined sufficiently for our present purpose.

It is necessary, before proceeding to a discussion of the subject, however, to say that the application of electricity to plant growing is of three general and more or less distinct types: 1. The direct application of the current to the individual plant, by means of which the plant is electrified. 2. The application of electricity to the soil. 3. Its application to the atmosphere. Unfortunately, these distinctions are not always kept in mind in discussions upon the subject, and erroneous conclusions seem to have followed the confusion.

1. Concerning the direct application of electric currents to plants, little of an exact nature can be said. It is well known—and my own experiments have shown it as well—that a mild electrical discharge will often seriously injure plants. A few discharges from a small Holtz machine will cause many herbaceous plants to wilt, and if the application is continued for an hour or so, the plant may die. On the other hand, there are various instances recorded in which beneficial results have followed the application of a mild and steady current, as shown in more rapid growth and earlier maturity of the treated plant. Yet we do not know whether such treatment can be employed to any practical extent, and it is highly probable that it will never become a powerful factor in horticultural practice. The most marked results with electrification are those in which the current has been applied to germinating seeds and ripening fruits, when it has been found, in many instances, to greatly hasten sprouting and ripening. It is probable that in this case the effect of the current is a chemical one in hastening the metabolism of the seed or fruit contents.

2. In the application of electrical energy to the soil, there are more definite results, yet the experiments are by no means uniform in their conclusions. In fact, there are the most opposed results, but this disagreement is no doubt very often due to unlike exterior conditions, and particularly to unlike species of plants which have been the subjects of experiment, and not to variation in fundamental action. This is well shown in the experiments of Warner, at the Hatch Experiment Station of Massachusetts, who was the first to enter this field in America. He found that parsnips, lettuce, salsify, radishes, and peas were benefited by the application of electricity to the soil; but under the same conditions, carrots gave indifferent results, while turnips and beets gave decidedly poor return. There was even a difference between varieties of the radish, the White Strasburg thriving better than the French Breakfast. But even at the best, this application of electricity so far promises little in the way of commercial results.

Although it is not my purpose to analyze the results of the various experimeuts in the application of electricity to the soil, I wish to submit a few suggestions in passing. In the first place, it has not been proved, so far as I know, that the effects are due to the mere electrification of the soil. It is quite as probable that the injuries or benefits follow some chemical or mechanical effect which the current may exert upon the soil or the interstitial air. But what I particularly wish to say is that I have not yet read of an investigation in this direction which satisfies the demands of exact experimentation. The electric plots in these experiments are provided with wires or metal plates beneath the soil, while the control plots are left in a normal condition. The placing of the apparatus in the soil requires the removal and replacement of all or a part of the earth, and the soil is therefore in a different and usually better mechanical condition than that of the control plots. Or even if the soil were to be removed and replaced in the controls, the presence of the wires and plates would of itself introduce a great element of error, for the wires would become important factors in aerating and draining the soil and probably in modifying its temperature; and metal plates would certainly be likely to influence soil temperature. It is well known that in certain cases the germination of seeds can be hastened by running a twig down to them: it becomes a means of providing oxygen from the air, and probably, also, of relieving the soil of some of its superfluous water. One of the important advantages of plowing under coarse manures or green crops is the mechanical effect which follows, for every strand of vegetable fiber forms a tube for the passage of water and air. And it has long been the practice in cool countries to put earthenware or other plates beneath fruit trees to warm their feet. While I am convinced that the application of electricity to the soil may produce marked effects upon vegetation, I shall not be ready to accept the results of experiments until the control plots are wired like the others—with non-conducting material, of course—and the temperatures and humidity of the soil are given careful attention.

3. It is very probable that atmospheric electricity exerts a powerful influence upon vegetation. The experiments of Grandeau, cited above, were designed to determine this point. Plants were grown in the free atmosphere, which is always in a greater or less state of electrification, and also in a wire cage from which the atmospheric electricity was excluded. Maize in the free air was in every way better than the other, not only in the bulk of all its parts, but in the amount of ash, and of both nitrogenous and non-nitrogenous matters. Leclerc, who made investigations at the same time, arrived at identical results. Grandeau's conclusions are as follows:

1. Atmospheric electricity exerts a considerable influence upon the production of vegetable matter. Other things being equal, plants will develop better when exposed to the influence of atmospheric electricity.

2. Plants deprived of the influence of atmospheric electricity have, in the same length of time, given 50 to 70 per cent. less bulk and 50 to 60 per cent. less fruit and seeds than the plants subjected to normal conditions; i. e., those to which atmospheric electricity has free access.

3. The proportion of albuminous matter does not appear to be sensibly influenced by the electricity, but those plants from which the electricity is withheld appear to contain less water and more mineral content.

4. Tall plants have a mischievous influence upon the development of those which grow at their feet, not only because they deprive them of heat and light, but also because they absorb the atmospheric electricity.

Celi, shortly afterward, reached similar results, while Naudin arrived at directly opposite conclusions. But the signal results obtained by the first three experimenters are generally accepted as strong evidence that normal atmospheric electricity is in some way beneficial to vegetation, and that in the experiments of Naudin there must have been some unknown conditions which obscured the results.

By far the best investigations upon the electrification of the atmosphere in reference to plant growing with which I am acquainted are those made in Finland and France, by Professor Lemstrom, physicist in the University of Helsingfors, with whom I have the pleasure of acquaintance. Lemstrom was first led to his inquiries by observations upon vegetation and meteorological phenomena—especially auroras—in the high north, particularly in Finnish Lapland and Spitzbergen, where he came to the conclusion that much of the rapidity of vegetation in the short summers is due to climatic electricity. His first experiments were made in the laboratory in 1885, and the results were so promising that he at once turned his attention to the field. During the summer of 1885, Lemstrom made an experiment upon a small field of barley, in Finland. One portion of the field was covered with small parallel wires a meter apart, and secured to porcelain insulators upon short posts at the margins of the field. At intervals of a half meter, each wire was furnished with a metal point from which the current could discharge into the atmosphere. This covering of wires was attached to the positive pole of a four-disk Holtz machine, which supplied the current. The current was applied from the middle of June till the first of September, from six to ten o'clock in the morning, and from five to nine o'clock in the evening. The barley was well up when the experiment began. The harvest showed that the electric plot was over 35 per cent. ahead of the remainder of the field in yield, and the quality of the grain was improved.

The following year, the investigation was continued upon a more extensive plan, with garden vegetables, and the results were strikingly interesting, although some plants did not thrive so well under the treatment as in normal conditions. The percentages of gain in edible products were as follows:

White beets	1 07	per cent. gain.
Red beets	65	" "
Potatoes	76	" "
Radishes	59	" "
Parsnips	54	" "
Leeks	42	" "
Celeriac	36	" "
Turnips	2	" "
Rutabaga	1	" "

Plants which showed loss were as follows:

Carrots	5	per cent. loss.
Kohl rabi	5	" "
Cabbages	43	" "

Two conclusions clearly follow from these results:

Atmospheric electricity, applied artificially, may exert a powerful influence upon growing plants; the character of this influence varies with the species. Here, then, is another illustration that the response of plants to external influence is a matter of adaptation with each individual species, and which is probably governed by the phylogenetic history of this type.

Experiments were also made in Finland in 1886 and 1887, upon cereals and potatoes, and the general results were very favorable. Aside from this fact, two general conclusions are stated by the experimenter, drawn from all the foregoing experiments:

1. The plants studied fall into two groups—

(a) Those in which the electricity favors the development:

Wheat,	Radishes,
Rye,	Celeriac,
Barley,	Leeks,
Oats,	Kidney beans,
Beets,	Raspberries,
Parsnips,	Strawberries.
Potatoes,	

(b) Those in which the electricity more or less hinders the development:

Pease,	Turnips,
Carrots,	Cabbages,
Rutabaga,	Tobacco.

2. The more fertile the soil, and consequently the more vigorous the vegetation, the greater is the harvest due to the influence of the electric current.

It now remained to determine whether the results obtained in Finland can be expected in other parts of the world, or if they are possible only in high latitudes. The scene of experimentation was now transferred to France, where cereals, garden vegetables, and a variety of fruits were treated. An incident in this experiment was the behavior of strawberries, which were subjected to an aerial discharge of from 2,000 to 3,000 volts continuously, night and day, from the middle of April to the middle of June. The first flowers appeared upon the 29th of April in the treated area and upon the 7th of May in the other portion. The treated plants were in every way superior to the others until the 18th of May, at which time there followed eight days of excessively hot weather. The treated plants languished, and the yield was much less than that of the normal area. The conclusion drawn from this interesting test is that the simultaneous action of electricity and high temperature is injurious to plants, and suggests that the electric current be discontinued in the hottest part of the day, as had been done in the Finnish experiments.

The season of 1888, in France, was abnormal because of the excessive rainfall and coldness of the summer, yet the general results of the investigations were encouraging, and justified the statement that "the effect of electricity produced by the method described is the same in the two countries, from which one may conclude that the effect will be the same in all parts of the globe." And it is further concluded that "the effect of the electric current depends to a certain degree upon external conditions or environments in which the plant is placed; or, in other words, the more favorable the external conditions, the more marked is the effect of electricity."

Although these remarkable experiments of Lemstrom have shown that the application of electricity to the atmosphere generally influences plants profoundly, and usually beneficially, it is yet undetermined just how this effect is brought about. It is highly probable, however, as Lemstrom himself suggests, that the modifications are not the direct results of electrification of the plants or the atmosphere, but rather follow some chemical change in the atmosphere which is engendered by the current. The experimenter is to continue his studies, and I expect to supplement them in America, for I consider it the most promising field in the many obscure interrelations of electric energy and horticultural practice. I expect little practical result to follow any method of direct electrification of vegetation, but there is promise in those broader applications which intensify the normal processes of nature.

THE ANAGLYPH.*

DUCOS DU HAURON, the noted French photo-scientist, whose researches and discoveries in the field of photographic optics are well known to almost all students of practical and theoretical photography, a short time ago exhibited before the Societe Francaise a number of pictures to which he gave the name of "anaglyphs." These prints were prepared by a novel method, and involved a new principle incident to the production of photo-stereoscopic effects.

Primarily, they were produced by the application of well-known principles of orthochromatic photography and the use of color filterers, which in connection with polychromatic positives culminated in the curious and interesting results shown to the Society; and when viewed under proper conditions produce a stereoscopic effect remarkable for its high relief and aerial perspective.

On the contrary, when the print is seen under ordinary conditions, it has the appearance of a confused blur, caused by a cliche being printed in two colors, one over the other, but without any attempt to register the superimposed impressions.

The word anaglyph is derived from the two Greek words meaning above and to cut—i. e., to cut in relief; and in ancient sculpture was a term applied to chased or embossed work on metal. In the present instance, Du Hauron has used it to denote simply a photo-stereoscopic effect.

As will be seen by an examination of the specimens here shown, viewed under ordinary circumstances the specimens seem to be nothing more nor less than a confused mass of blue and red ink—one picture printed upon another in a different colored pigment.

The inscription calls this blurred image, or "wirrwarr," as a German scientist aptly calls it, "A view of the Archeological Museum in the Trocadero, Paris."

Now take this same nondescript polychrome, and view it in a strong light through a pair of spectacles where one glass is red and the other blue; the result is magical. We have a black picture before our vision wherein the stereoscopic effect is marvelous. The column in the center stands bodily out, the sculpture has taken shape, the bass-reliefs, cameo-like, embellish the sunken panels, while the eye wanders down the long corridor which ends in a graceful curve in the distance. Such is the anaglyph.

Now take another glance at the ordinary photograph, from the same standpoint, and remark how flat and ordinary it looks in comparison with the wonderful depth of the anaglyph.

Ducos du Hauron, in a letter to his friend Demole in Geneva, states that according to his latest experiments an anaglyph composed of two colors only, and seen with a bichromatic eyeglass, the colors of which are suitably chosen, is capable of producing upon the organ of sight a sensation of color more complete than that which seemingly ought to result from the quality of its constituent elements.

Thus, in practice, in order to produce the red plate, it is sufficient to use a phototype obtained by the intervention of a medium green, and for the blue plate one obtained by the intervenient agency of a medium orange red. In consequence of a curious illusion, the eyes equipped with a red and a blue glass seem to perceive in the charming picture which results, not only the tints shading from the red to the blue, but also from those each of these colors, or even yellow, which nevertheless is absent. The effect becomes more pronounced when for the ruby-red eyeglass a very dark yellow glass is substituted. It is nevertheless advantageous to moderate the difference between the tint of this yellow glass and that of the monochrome, which it is destined to efface for the left eye. If, for example, madder lake be used for the printing color instead of vermilion, which has thus far been employed for the purpose, red margins would appear in the outlines of the image, rendering somewhat difficult the perception of the relief.

Experiments thus far have failed to show that any sufficient advantages were to be gained to justify a recourse to Du Hauron's original method of photography in three colors, that is, by an addition of a third plate produced through the medium of a violet light, thereby producing the yellow monochrome appertaining to the perspective of the right eye.

Du Hauron goes on to state that it seems to him that until something better is discovered one should be limited to putting into practice the empiric law which he has already given, namely, take the phototype of the red with the intervention of a medium green, and that of the blue with the intervenient agency of a medium orange red. It will be best, Du Hauron goes on to state, to employ orthochromatic plates; for example, for the phototype obtained with the medium green, plates of what are known as "Light Series A," sensitive to yellow and to green, and for that obtained with the medium orange red, plates of "Light Series B," sensitive to yellow and to red.

It is needless to say that in the anaglyphic process all ideas of instantaneous exposures or snapshots are out of question.

Dr. E. Batault, an eminent Swiss scientist, in commenting upon the optical problems involved in the production of the anaglyph, gives the following explanation of the scientific features embraced in this special branch of photo-stereoscopy, viz.:

It has been known for a long time that the sensation of relief and aerial perspective is due to binocular vision. Both of our eyes, in fixing an object, do not see it at the same angle, and accordingly not exactly in the same manner, and it is the sensorial superposition of the two pictures thus obtained which gives rise to the idea of depth.

The general problem of stereoscopy consists, then, in presenting to each eye the picture of an object as it would see it, and from the cerebral or subjective superposition of these two pictures will arise the impression of real relief of the thing represented. But just here comes a slight difficulty. If we present to our two eyes two pictures slightly dissimilar, for example, two photographs taken from two points as far apart as the eyes are distant from each other, each eye will see, not only the picture corresponding to that which it receives of the reality, but also the two at once, because of the extent of the field of vision.

Moreover, if the left eye fixes the center of the left picture, the right eye immediately converges toward the same point, instead of directing itself toward the center of the right picture. If we suppose, as is necessary, that the distance between the centers of the two proofs be equal to that between the eyes, it will be necessary, in order that each eye may regard the corresponding point in each of the pictures, that the view be unbounded, for in that case the optical axes are parallel. Now, the eye contains an optical apparatus, the crystalline lens, which does not admit steady focusing for all positions, but which, on the other hand, has the wonderful property called accommodation. This gives an instantaneous and automatic focus for a certain distance and it calculates that distance in a mathematical, trigonometrical manner, the power for which is furnished by the convergence of the eyes.

The vision consequently is caught between two alternatives equally defective; either each eye is directed toward the center of each of the pictures, in which case we see indistinctly, because, the optical axes being parallel, clearness exists only for objects at a distance, or we see distinctly, but in the latter case the two eyes are directed upon one of the two photographs. In order to obtain at the same time a distinct view of a single picture by each eye, an artifice must be employed. The ordinary apparatus known under the name of the refracting or Brewster stereoscope solves this problem for us. Indeed, by interposing between the eyes and the proof two prisms, ridge to ridge, suitably choosing their angles, one can have the virtual superposition of the different points of the two pictures, and in consequence the relief, while allowing the eyes to converge to the same degree as in ordinary sight, precisely the result sought. The angles of the prisms may vary within certain limits, for an exact accommodation may be had by varying their distance from the pictures. By this process, there would be seen, in spite of all, three pictures, a middle one in relief and two plates. These last two may be destroyed by placing between the two prisms, and perpendicularly to the proof looked at, an opaque partition limiting the field of vision of each eye. The same end may be reached by disuniting by practice the convergence of the accommodation, that is, by provoking an artificial strabismus, but that is a slow, tedious process and of but little practicability.

After the general considerations we can define an anaglyph as a stereoscopic effect produced by colored pictures.

Let us suppose that there are printed, in two different colors, upon the same sheet of white paper, two stereoscopic designs in such a manner that their corresponding points may be quite near to each other. Let the selected colors, which should differ greatly, be blue for the left picture and red for the right. At first sight, these two proofs, according to what we have just said, will be mingled together partly confounded, and will present a mixture but little agreeable and still less comprehensible. But if we look at them with the aid of an eye glass, having a red glass before the left eye and a blue one before the right eye, the scene changes immediately, and to the previous chaos succeeds a harmonious and satisfying impression of relief and perspective. What has happened? A fact which upon first consideration seems somewhat paradoxical, or at least incomprehensible; the left eye, equipped with a red glass, can see the left picture only, which is blue, the second picture, red, representing the other proof, becoming invisible because a red design upon a white ground is not perceptible in red light. For the same reason the right eye sees only the picture which is destined for it, and the stereoscopic superposition instantly follows.

The convergence and the accommodation are both satisfied, because the two designs present only an insignificant distance apart and within the limits in which the focusing is still sufficiently exact. Moreover, the pictures may be of any size, since whatever their dimensions they can always be printed as near to each other as desired, or, indeed, one upon the other.

In order that the effect may be a complete success, certain other conditions are necessary. The designs should be of tints sufficiently light and the glasses of the spectacles dark, accordingly it is necessary to employ an intense light, without which, considering the great absorption of light, the result is dull and dark. If the rays reflected by the designs and admitted through the glasses were absolutely monochrome, the pictures would appear in black upon a background formed by the mixture of the two adopted colors. In fact, a picture emitting blue rays only should become black in a red light, since all the rays which it reflects are arrested by the red glass, that is, it is presented under the appearance of a design without color upon a monochromatic background.

Whether this new process of obtaining stereoscopic effects, which requires the co-operation of the photographic processes, and a sufficient knowledge of the theory of colors, will ever be of any practical value, is hard to foretell.

It is evidently not a process for amateurs, upon the other hand it is one of intense interest in a theoretical and scientific point of view. For the unversed it is a curiosity.

To the general public it will prove a scientific problem, the solution of which is to be found in a pair of spectacles, and in virtue of this it may be destined to attract some attention outside of the scientific circles.

In conclusion I will state that at various times experiments have been made to utilize this principle of superimposition, both in monochrome and color, together with bichromate glasses to produce stereoscopic effects upon the screen by the aid of a biunal lantern.

The latest successful attempt was, I believe, made by Anderton, of London, who used ordinary stereoscopic transparencies, that were cut in two and used as ordinary lantern slides. To produce the anaglyphic effect he polarized his light by aid of two bundles of glass plates in lieu of Iceland spar. These were placed at some distance from each other, the first bundle of glass plates acting as a polarizer, the second as an analyzer. The image was projected through this combination in the ordinary way upon the screen, but the colors did not coincide.

To bring out the stereoscopic effect, as is the case in the specimens of the anaglyph now before the society, a special lorgnette was provided for each spectator which was to act as an analyzer; in this case they were of white glass.

The screen was coated with silver foil, as every substance except a metallic one that reflects light also polarizes it.

Stereoscopic projection in two colors, red and blue, have also been attempted upon an ordinary screen, the analyzer being a red and blue bichromate lorgnette, as is the case before you. The results, however, were not a general succession account of the difficulty experienced in determining the correct distance apart of the superimposed images upon the screen, and in obtaining the proper shades of lenses for the eye-glasses, which to bring out the maximum effect must coincide with the colors used in the print or projected image.

* Read by Julius F. Sachse before the Photographic Society of Philadelphia, November 14, 1894.—American Journal of Photography.

LUMINESCENCE OF GLASS.

AT the last meeting of the London Physical Society Mr. Burke communicated a paper "On a Suggestion of Prof. J. J. Thomson in Connection with the Luminescence of Glass Due to Cathode Rays."

More than a hundred years ago Beccaria observed that when vacuum bulbs were broken in the dark a light consisting of a faint glow was produced in the place where the bulb lay. Beccaria was led by his experiments to attribute this effect to the rushing of air against the glass walls of the exhausted vessel; and in his "Recent Researches in Electricity and Magnetism," Prof. J. J. Thomson indicates its possible close relationship to Mr. Crookes' theory of the luminescence of the glass in Geissler's tubes. The author, however, has made numerous experiments on the breaking of glow lamps, and on the admission of air to an exhausted chamber by the breaking of a thin plate of glass or of a piece of bladder closing an aperture in the walls. In these cases, and in other cases where it was possible for fragments of solid to be projected against

the walls of the vessel, a luminous appearance was obtained; while in other cases, where such solid fragments would be absent, no luminosity was observed. The author concludes that Beccaria's phenomenon was due to the impact of glass against glass, and not to the rush of air against the walls of the broken vessel.

SINGLE RAIL RAILWAYS.

LIGHT railways are successful whenever there is proper use for them. This is the case in agricultural matters, but possibly the greatest benefit will result from their employment in industrial pursuits.

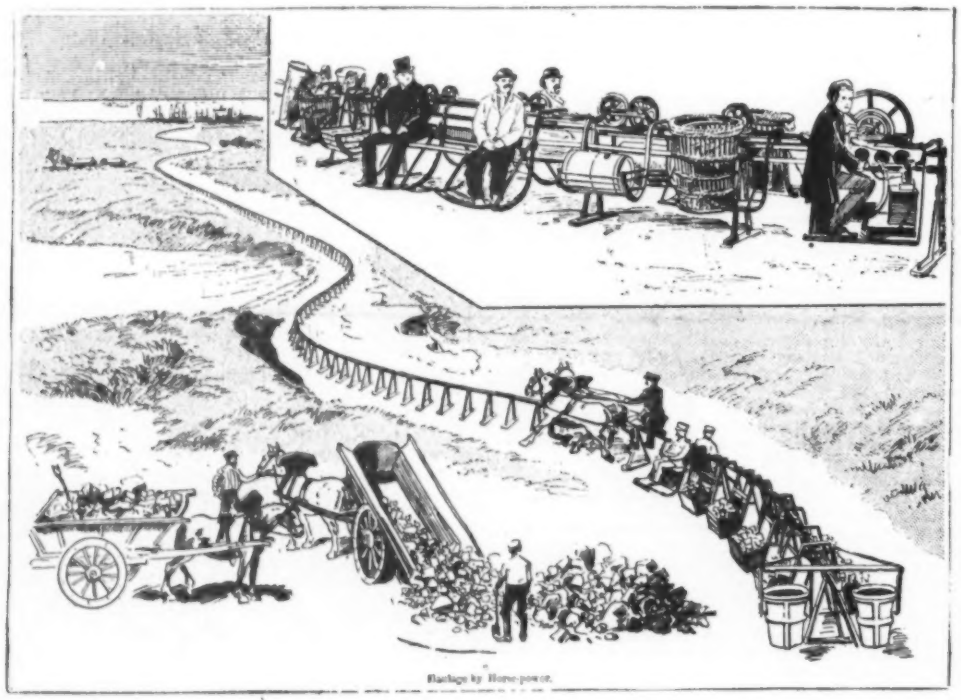
The "Lartigue Balance Railway" may be considered the newest and cheapest form now before the public.

EXPERIMENTS IN ENGLAND.

The success of Decauville's system was very decided where I first saw it in work on a large scale in Holland, carrying its truckloads of turf or of excavated polderland in the most satisfactory manner. It was also favorably seen and approved by some Norfolk farmers with whom I visited the Dutch dairies some ten years ago, and saw various farms of which the produce was carried by the proprietor's own private miniature railway. Subsequently Messrs. Fowler did introduce this little railway into England, and conveyed passengers round the showyard of the Royal Agricultural Society. Our dockyard authorities at Chatham adopted the system about 1880. Since then, here and there a few agriculturists and market gardeners have had laid down the two-foot wide metal permanent and portable railway, in most cases to run through their own grounds only, either to a point of a high road or to a quay where the goods could be embarked. For the use of the public, "little railways" can only be said to exist in this country, except to a very small extent, as feeders to main lines.

THE SINGLE RAIL.

But, as I have indicated, the County Council have



Haulage by Horse-power.

A SINGLE RAIL RAILWAY.

powers which probably may be exercised apart from the restrictions of the Board of Trade, and be free to make such easy regulations as will enable these half and half railways, half and half horse machines, to be used on common roads. The opportunity has come, and experience abroad shows it should be used. What the best system may be will be determined by the uses to which the light railway is to be applied. Undoubtedly there are great claims for what is called the "Monorail," or the "Lartigue Balance Railway," which has been successfully used in Algeria and Russia, as in France. The haulage may be by men or animals. The inventor, M. Lartigue, told me that the idea came to him of a railway above ground, which rail should have, like the backbone of mules, an apparatus suspended on either side like panniers, which, balancing, should run on grooved wheels on the single rail. In a short time a railway several miles in length was constructed and worked successfully to bring to market a material that before had been valueless, through its cost of transit. We give illustrations. At the Algerian Agricultural Show this "Balance Railway" received its first medal. The rapidity with which it is constructed, its great cheapness in making and working are great recommendations. A couple of workmen can set up several hundred yards of the line in a single day, and the haulage power necessary to move the load on this system is 30 per cent. less than is required upon ordinary double rails.

CONSTRUCTION AND OPERATION OF SMALL STREET RAILWAYS*

By W. WORTH BEAN.

CONSTRUCTION, maintenance and operation of small street railways is the subject on which the president has requested me, as a committee of one, to prepare a paper to be read at this meeting.

* A paper read before the Michigan Street Railway Association.—Street Railway Review.

First.—In the construction of small street railways as much care must be taken and even more than in the building of large street railways. Proper and substantial roadbeds must be prepared in order to receive the ties and rails. White oak ties of the best quality should be used, varying from 2 feet to 2 feet 8 inch centers. Ties 5 by 7 inches and 5 by 8 inches, 7 feet long, should be used, according to weight and height of rails, except joint ties, which should be 6 by 12 inches, 7 feet long. Every tie should be thoroughly tamped. Steel rails of girder and T pattern and first-class splices and nuts and bolts should only be used, according to location and surroundings, and rails put to perfect gauge and the track lined and surfaced in the best possible manner. The writer finds in sandy districts that 3 inch by 10 inch and 3 inch by 12 inch pine plank, 12 to 16 feet long, properly nailed to cross ties, and plank 3 inches by 12 inches wide placed on the outside of the rails makes a thorough and complete construction, which braces the track in every way, and also makes an excellent road for wagons and buggies to cross over and drive on. If permitted by city councils, the head of the rail should extend at least one-half inch above the plank and the grade of the street. The greatest error that has prevailed heretofore, with few exceptions, has been the cheap and imperfect manner with which small street railways have been constructed. The idea has been to see how cheap a small street railway could be built by having hemlock and cedar ties of small dimensions placed too far apart, and rails of too light a pattern, both put down in the cheapest possible manner, so that all that can be said is that a street railway has been constructed. Curves and switches should also be made of T and girder rails of the latest and best approved patterns, and constructed in the best possible way known to street railway building. Great care should be taken to see that every joint is thoroughly bonded with large, soft-drawn copper wire and channel pins of the best manufacture. From experiments already made and the actual construction of tracks in Boston and St. Louis, it seems that the era of a new day has dawned upon us by the use of the continuous rail and the eliminating of bond wires, the splice bars, nuts and bolts, and sinking of joints, which is so disastrous to tracks and cars. With electrolysis eating and corroding the water and gas pipes in various cities, as published in different journals, the breaking and disconnecting of bond wires at the joints and return current going in the ground, which costs money at the coal pile, it is hoped the year of jubilee has come in the construction of street railways. If the streets through which small street railway tracks are laid, or are to be laid, are paved, or are to be paved in a short time, brick or asphaltum should be used with the continuous rail (provided the company has the necessary funds), which, to the mind of the writer, would almost be a perfect track.

Overhead Construction.—The overhead construction of an electric railway should be put up of the best and most substantial material that can be bought. Iron poles ought to be set in the business portion of the city and cedar in other parts. Switches, frogs and overhead curves should be of the safest and best construction. Feeder wires of large size, with good insulation, should be put on the poles in a substantial manner, and lightning arresters connected at short distances along the line or where feeders are connected with the trolley.

Second—Maintenance.—In keeping in repair street railway tracks, the first important thing to observe and do is to keep the tracks at perfect gauge at all times, as well as in line and surface. The bond wires should be tested by taking instrument readings at frequent intervals, and defective ones should be replaced at once, for economy at the coal bin or oil tank. If the continuous rail is used, only gauging, lining and surfacing need be done. Roadbed and tracks should be well drained and kept free of snow and ice, so that water cannot settle around the ties, and lower the joints and rails by motor and trail cars passing over the same. Frequent inspection should be given the lightning arresters and overhead construction, and all kept in good repair.

Third—Operation.—Last, but not least. The operation of small street railways has a checkered career. In the first instance, to build and maintain a small street railway, as above described, or as some railways have been constructed, and operate them with economy, is what presidents, general managers, superintendents, directors and stockholders have been looking for. In operating a street railway in summer, there are two motives for keeping the rail free from dirt and sprinkling the track: First, that the motors may be kept clean and in perfect order. Second, that the passengers may not have a cloud of dust following them by day and night, and making their lives unbearable, as well as spoiling their clothes. This is all different from operating in winter, when sleet and snow fall on the tracks and trolley in all their force and fury, and all the vehicles in your particular community seem to be on the tracks in front of the cars to cover the rails, that have just been cleaned, with snow. It is then that a manager thinks his burdens more than he can bear. To make a small street railway a dividend payer, and to have genuine and unadulterated business fun, add 100 arc lights and 2,000 incandescent lights to your street railway service, and put a telephone in the station and one in your house, and then you have a first-class electric circus. I am a firm believer in the electric car heater after two winters' service, and do not see how electric heaters can be dispensed with. Great care should be taken in the selection of motormen and conductors, and all reasonable rules rigidly enforced to prevent accidents from front ends of cars, and to look carefully after passengers at rear ends of cars, and, most important of all, collect and register all fares. The oasis in the desert, if there be such, for the manager, is to provide for the entertainment of passengers along and at the ends of the lines, to keep up the revenue, and make the stockholders financially happy.

The past summer the writer has had comedy companies, distribution of groceries, bands of music, picnics, dances, etc., at the pavilion terminus of his line, and they have all largely increased the revenue of the company.

As each year rolls by, it is to be hoped our ways and means will not be exhausted to largely increase travel, in the operation of small street railways, which are so essential to small towns and suburban districts and the entire growing population. The writer commenced the construction and operation of a small street railway in Kentucky in 1879, and is much pleased with the great strides made in the street railway field in so short a time.

EXPERIMENTS IN AERONAUTICS.*

By HIRAM S. MAXIM.

IN the winter of 1856-57, when I was sixteen years of age, my father worked out a plan of a flying machine. It consisted of a small platform which he proposed to lift directly into the air by the action of two screw propellers revolving in reverse directions. One of the screw propellers was to be placed about 10 ft. above the other, and the shaft of the lower one was to be tubular and made to rotate on the outside of the shaft driving the upper screw. He had studied out a system by which the relative action of the two screws could be changed, so as to prevent the machine from rotating in either direction. For a motor, he proposed to employ some kind of an explosive material, gunpowder preferred, but I distinctly remember that he said if an apparatus could be successfully navigated through the air, it would be of such inestimable value as a military engine that no matter how much it might cost to run it, it would be used by governments, even if the engines had to be driven by an explosive as costly as fulminate of mercury. A year or two later, the well known Peter Cooper, of New York, actually commenced a series of experiments with a view of constructing a machine to lift itself directly into the air by means of screw propellers on vertical shafts. He proposed to drive his screws by means of engines utilizing the explosive force of chloride of nitrogen. I do not know how he proposed to handle so sensitive and dangerous a compound, but from what I have learned from his grandchildren, I believe he intended to produce the explosive as consumed. However, he had not gone very far with his experiments when a premature explosion injured the sight of one of his eyes, and he then seems to have abandoned the whole thing.

I believe that almost every one, when they commence to study the question of aerial navigation by means of machines heavier than the air, first think of lifting the machine directly into the air, either by the agency of wings or by screw propellers working on vertical shafts. I remember some twenty years ago, when I myself commenced to think of the subject, that my first idea was to lift my machine by vertical propellers, and I actually commenced drawings, and made calculations for a machine on this plan, using an oil motor something like a Brayton engine for my motive power. However, I was completely unable to work out any system which would not be too heavy to lift itself directly into the air, and it was only when I commenced to study the aeroplane system that it became apparent to me that it would be possible to make a machine light enough and powerful enough to raise itself without the agency of a balloon. From the very first I was convinced that it would be quite out of the question to employ a balloon in any form. No matter from what point the question was considered, I always found that if a balloon was large enough to be of any practical value in lifting a machine, it would be large enough to prevent its progress through the air.

A flying machine to be of any value must of necessity be able to propel itself through the air at a velocity greater than that of an ordinary high wind; it ought at least to be able to travel at a velocity of thirty-five miles an hour. At this speed I found that a small and cheap aeroplane would lift more for its weight than a balloon, and would require vastly less to propel it. Therefore, in an actual flying machine, the balloon appeared to me to be, not only useless, but impossible. If large machines could be made with sufficient power to lift themseves vertically into the air, experimenting with them would be comparatively

* Read before the Society of Arts, London, November 28, 1894. From the Journal of the Society.

simple, because no large field would be required, but with the aeroplane system, which may be considered a kite, or perhaps a system of kites, and which must rise at an angle, it is necessary that the machine should have a long run in order to attain the required velocity for rising, otherwise it would be necessary to find some place where a strong gale could be relied upon, when the machine might be anchored to the earth and be flown in the air after the manner of a kite. I ascertained that there were canons in California where a forty-mile gale, always in the same direction, could be relied upon in the afternoon nearly every day in the year. I determined to obtain a place in one of these canons and to construct my machine after the manner of a big kite, having one or more aeroplanes. I should have anchored it to the top of a tall post and commenced my experiments by flying it without any motor. The first experiments would be with the steering apparatus, and not until I should be able to maintain the apparatus in the air on an even keel, and at the exact height of the post to which it was anchored, would any experiments be made with the motors. A dynamometer would be introduced into the wire ropes securing the machine to the top of the post. This would indicate the tendency to drift with the wind, while the lifting power of the machine could be easily tested by attaching weights. In this manner it would be possible to experiment with all sorts and sizes of aeroplanes, and to ascertain which would lift the greatest load and have the least tendency to drift with the wind. The next experiment would be with the engines and propellers. When the machine was raised in the air, the engines could be started and the screw thrust accurately determined by the dynamometer, before referred to. When the engines and propellers had been so perfected as to completely slacken the rope which held the machine against the wind, it might be considered that the machine was actually flying. This is about as simple and as effective a system of experimenting with a machine of this kind as could be imagined, but I was unable to go to California, and had to content myself by conducting experiments in England.

As I could not rely upon the wind to raise my machine, it was necessary for me to drive it through the air, and for this purpose I procured a large field, 1,800 ft. broad, where I laid down a light railway track on which my experiments have been conducted.

In regard to motors, as before stated, I first studied the oil engine. Brayton's motor was the first oil or gas engine ever produced which gave fair results, and it may be considered as the parent of all the recent economical engines using internal combustion. I was, however, at that time unable to design an oil engine which was light enough for the purpose. The next one considered, and the one which has always figured out much lighter than any others, was a naphtha engine in which naphtha instead of water was used in the boiler. The experiments of those very able engineers, Messrs. Yarrow, have clearly demonstrated that a great deal more work per unit of heat may be developed by the use of naphtha than by the use of water in the generator, because a much less quantity of heat is carried over in the exhaust. Moreover, the temperature is much lower, and as there is no tendency to rust, very light steel tubes may be used in the generator. But the element of danger was so great that I was forced to abandon this idea.

The next motor to be considered was a steam engine, and this is the motor which I am employing to-day. I commenced my motor experiments with a view of ascertaining how much water could be evaporated from small copper tubes, and having obtained a quantity of these, $\frac{5}{8}$ in. external diameter and $\frac{1}{20}$ in. thick, I mounted four of them in a white hot furnace, and found that I could evaporate 26½ lb. of water per hour from a square foot of heating surface; that the tubes would stand more than a ton pressure per square inch when cold, and that under steam pressure they only burst at 1,650 lb. pressure per square inch. I also found that with a forced circulation, although the quantity of water passing was very small, but positive, there was no danger of overheating, even with the hottest kind of a fire.

I next made a boiler 8 ft. long, 4½ ft. wide and 6 ft. high, having, altogether, about 800 square ft. of heating surface. The weight of this boiler, with its feed water heater, its casing, the dome and the smoke stack and connections, was very nearly 1,000 lb. It was first tested with a cold water pressure of 410 lb. to the square inch and then with a steam pressure of 330 lb. to the square inch.

Having completed my boiler, the next step was to experiment with a gas generator and burner. One of the first burners which I used was made almost entirely of sheet nickel, but this became so very brittle after running a few days that it was quite impossible to use it. I then made a steel burner similar to the one shown. The first burner had many more tubes, and no less that 14,000 jets. One-half of these tubes were removed and the rest shortened, when much better results were obtained. After considerable experimenting, I found that common naphtha, 72° Baume, was the most suitable for fuel.

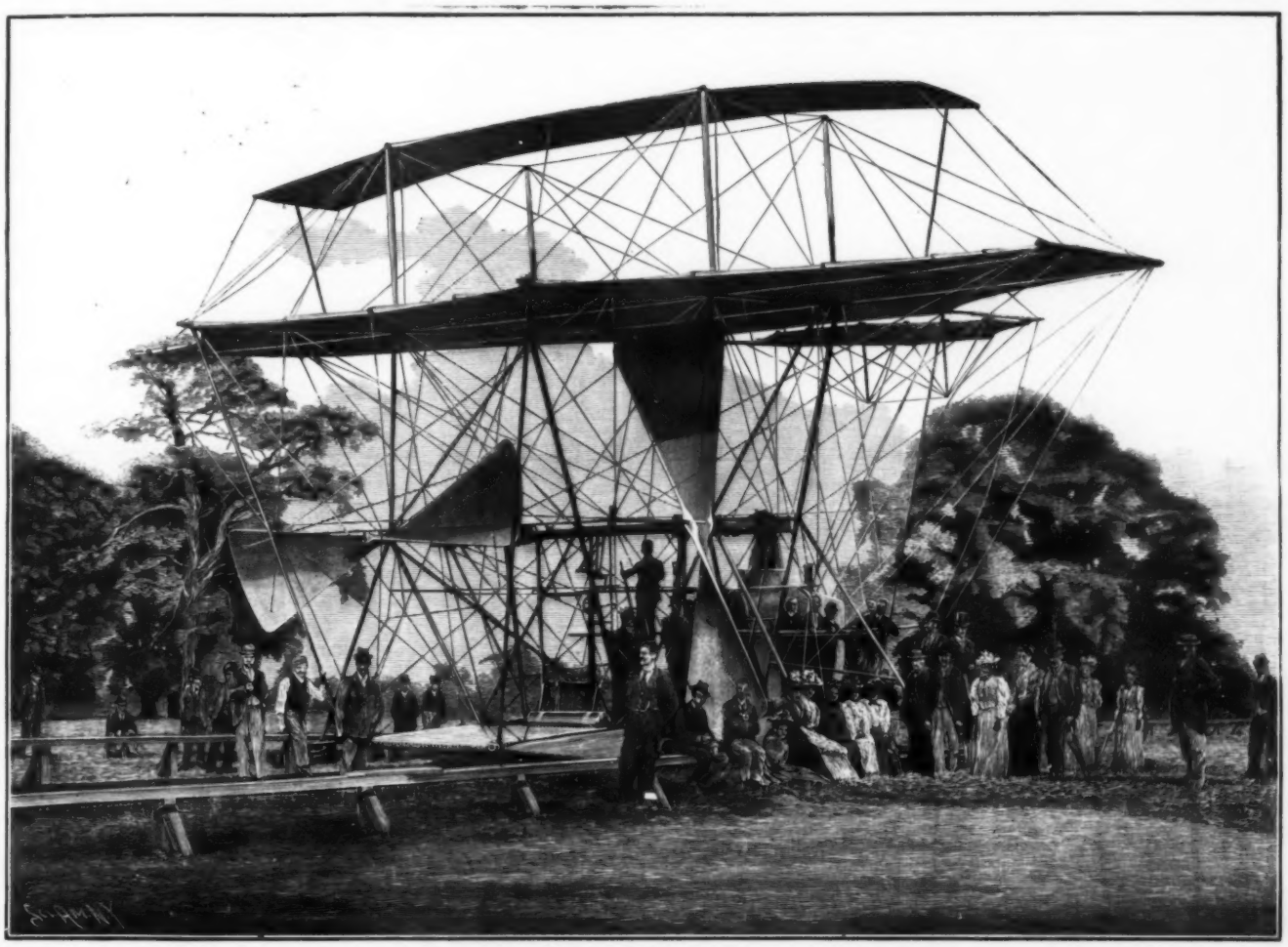
The gas generator consists of a small vertical boiler made of very thin and strong steel, all the joints being silver soldered. This generator is constructed in such a manner that a certain portion of the tube sheets is flexible. A central hollow stay bolt is provided with a valve, and adjusted in such a manner that when the pressure in the generator is less than 50 lb. per square inch, a portion of the gas passes downward through the stay bolt, and escaping through a species of Bunsen burner, furnishes the heat for generating the gas. The generator is therefore heated by a portion of its own contents. In case the pressure should rise above 50 lb. per square inch, the tube sheets will be sprung outward, the valve closed, and the gas supplying the heat shut off. The pressure is therefore automatically regulated in a very simple and efficient manner. The generator is mounted on a bell crank lever and supported by a spiral spring. When the weight of naphtha in the generator is less than 40 lb., the generator is raised, which operates on a mechanism which shortens the throw of the naphtha pump at each stroke. This apparatus is found to work admirably, and no matter whether a large or a small quantity of gas is being consumed, the weight of naphtha in the generator never varies more than a pound. The gas from the generator is superheated by passing through the fire box of the boiler; it then passes through a regulating valve, and finally through an adjustable jet, where its force is employed to draw in a large quantity of air, which becomes thoroughly mixed with the vapors before they escape through the burners. The holes in the burner pipes are so placed and arranged that one jet strikes another at such an angle as to prevent them from being blown out, and, at the same time, induce a strong current of air from the bottom. This furnishes the necessary draught, without the aid of a fan blower or steam jet.

The steam engines are made, for the most part, of a high grade of steel, many of the parts being tempered. There are two high pressure cylinders each 5 in. in diameter, and two low pressure cylinders each 8 in. in diameter; they are double acting, and all have a common stroke of 12 in. The steam pressure used is from 275 lb. to 320 lb. per square inch, and the number of revolutions is from 300 to 400 per minute. It is found, by experiment, that the boiler is able to make a great deal more steam than the engines are able to consume. A by-pass is provided which admits of allowing the high pressure steam to pass directly into the low pressure cylinder. In passing through a species of injector, a fall of about 200 lb. in pressure is made to do work on the surrounding steam in such a manner that the direct pressure in the low pressure cylinder is increased to considerably more than the back pressure on the high pressure piston.

Before completing my large machine, I conducted a series of experiments on a much smaller scale with an apparatus similar to that employed by Professor Langley in his well known experiments. At the time, however, I did not know that Professor Langley was making any experiments, and my apparatus was constructed quite independently of his. The results of our experiments are very nearly alike. I mounted a long arm on a central pivot, the length of the arm being sufficient to make the circumference of the circle around which it traveled exactly 200 feet. To the end of this arm I attached a small apparatus, and transmitted power to it through the central pivot and the radial arm. This apparatus was constructed in such a manner that it enabled me to ascertain with a great degree of nicety the exact power required to drive the plane through the air, the lift of the plane, the thrust of the screw, the slip of the screw, etc. A great many forms of screws were employed in these experiments, some being plain, some with increasing pitch, and some with a compound increasing pitch. In a screw propeller, working in water, the best results are obtained when the points of the blades are made rather narrow, but with a screw running in the air, where the skin friction is so small a factor that it need not be considered, there is a decided disadvantage in reducing the width of the ends of the blades. The results of my experiments have shown that a well made screw is a fairly efficient aerial propeller.

The large screws which I employ in my machine are 17 ft. 10 in diameter, and have a pitch of 16 ft. The width of the blade at the tip is about 5 ft. The weight of the screws is 135 lb. each before painting, and I have applied as much as 180 horse power to one of these screws.

A great many experiments were also made with different forms of aeroplanes, and it was found that as much as 133 lb. could be carried with the expenditure of one horse power with a well made aeroplane. Long and relatively narrow planes were found to be more efficient than very large ones, and superposed planes were found to work well provided they were not placed too near together. With very narrow superposed planes, I have found that it is possible to lift a very large load per square foot, but if the planes are ar-



MAXIM'S FLYING MACHINE.

ranged one above the other, it requires a good deal of power to drive them through the air. Suppose, for instance, that the planes should be $\frac{1}{10}$ in. thick, and be placed 2 in. apart, and that they were driven through the air at the rate of 40 miles an hour. The planes occupying one-twentieth part of the whole space would either have to drive the air, in which they were traveling, forward at the rate of two miles an hour, or the air would have to be spun out and pass through the spaces between the aeroplanes at the rate of 42 miles an hour as relates to the planes. I have found this arrangement to be so wasteful in power as to give very narrow superposed planes little or no advantage over well made large planes placed in such a position as not to cause this particular action on the air. However, narrow planes may be advantageously employed, provided they are made very thin, and, instead of being superposed one immediately over the other, are arranged after the manner of a flight of stars or zigzag, that is, in such a manner that the air is able to pass freely between them when they are being driven forward, the arrangement being such that the sum of all the spaces is nearly equal to the total area occupied by all the planes. In this way I am able to obtain a large lifting effect per square foot, and at the same time greatly reduce the amount of power necessary to drive the planes through the air.

Notwithstanding that my first experiments on a small scale demonstrated conclusively that small and narrow planes were somewhat more efficient than large ones, I determined to use very large aeroplanes on my machine at least with my first experiments. No matter how efficient the small superposed, inclined or zigzag aeroplanes might be while traveling through the air at a high velocity, their resistance against falling in case of a stoppage or a breakdown of the machinery would not be anything like as efficient as a very large plane. It will be easy to understand that if a machine is provided with a very large plane, in case of a stoppage, the whole apparatus becomes, as it were, a parachute, and a very rapid and destructive fall to the earth is absolutely impossible.

All my experiments went to show that an aeroplane in order to be efficient must be very rigid, and not be deformed by the pressure of the air, and I found that it was not at first an easy matter to make a large aeroplane which would fulfill all the requirements. After a great many experiments I constructed an aeroplane, the framework of which consists of very strong but thin steel tubes stayed with strong steel wires. The underneath side of this framework I covered with a fine quality of balloon material, slightly varnished, but not sufficiently to prevent a small quantity of air from passing through. The top side of the framework was covered with the same material, but varnished sufficiently to make it absolutely air tight. The bottom was stretched very taut over the whole surface, and was only held to the frame at the edges and by two lines through the center, while the top was drawn over the framework rather loosely and secured to it not only at the edges, but also in parallel lines about six feet apart. The fore and aft rudders are covered in a similar manner. As the aeroplane is run rapidly forward a certain portion of the air passes through the underneath side and sets up a pressure between the upper and lower coverings. The top side takes the load and bags upward between the supports. This forms corrugations in a longitudinal direction, which offer no perceptible resistance to the air; whereas the bottom, by having practically the same pressure on both sides, is not distorted in the least. The aeroplane is found to be nearly as efficient as it would be if cut out of a solid piece of wood. Both the fore and aft edges are made exceedingly sharp, the cloth being laced together over a thin but strong wire. The figure of the main aeroplane is, approximately, octagonal.

In my early experiments, I generally placed my aeroplanes at an angle of 1 in 14; that is, at such an angle that in passing ahead 14 inches, they pressed the air down one inch. I find it more convenient to express the angle in this manner than in degrees. With a well made and very smooth aeroplane placed at this angle, I can rely upon a lifting effect of 14 lb. for every pound of screw thrust imparted to the aeroplane, the skin friction being so small as to be negligible. With a large machine, however, and only a short railway track, I decided to mount my aeroplanes at an angle of 1 in 8, so as to get a large lifting effect with a relatively low speed. When my large machine was finished it was found to weigh very nearly 8,000 lb. while standing still, with the men, the water, and the fuel on board; but when run over the track with a steam pressure of about 275 lb. per square inch, the weight on the track became nil. It will be understood that these experiments are being made on a railway track, which consists of ordinary light steel rails about 8 ft. gauge. Outside and above these rails is another track of 3 in. by 9 in. Georgia pine, the gauge being about 30 ft. The machine is provided with two complete sets of wheels, one for running on the lower steel rails, and the other for engaging the wooden track when the lower wheels have been lifted one inch clear of the steel rails. At a steam pressure of 275 lb. per square inch, I found in my last experiments, after about 600 ft. of the track had been covered, that the machine vibrated, running part of the time on the lower steel rails and part of the time on the upper track. But when the steam pressure was increased to 320 lb per square inch, all four of the upper wheels were kept in constant contact with the upper track, and when about 1,000 ft. had been covered, the lifting effect became so great that the rear axletrees were doubled up, the rear end of the machine lifted up about 4 ft., and finally one of the front wheels tore up about 100 ft. of the upper track, when steam was shut off, and the machine dropped to the ground without any great shock. One of the timbers of the upper track lodged in the lower framework of the machine, causing considerable damage, but all the machinery, with the exception of one of the screws, escaped injury. At the time this accident occurred the screw thrust was about 2,000 lb. and the engines were developing 362 horse power. The boiler, however, was not running at its full capacity. The parts of the machine which were damaged on this occasion have now been repaired, and I am strengthening some of the stays and braces, so that in my next experiments, if I find it necessary, I can run the engines up to 400 horse power, or even more; but in order to do so, I shall allow a certain amount of the live steam to pass directly into the low pressure cylinders, as before referred to, so as not to allow the boiler pressure to mount to more than 300 lb. to the square inch.

The machine is provided with a fore and aft rudder, both of which are connected to the same windlass. If the front rudder is placed at an angle considerably greater than that of the main aeroplane, and the rear rudder placed flat so as not to lift at all, and the machine run over the track at a high speed, the front wheels will be lifted from the steel rails, leaving the rear wheels on the rails. If the rudders are placed in the reversed position so that the front rudder is thrown out of action and the rear rudder lifts to its full extent, the hind wheels will be lifted from the steel rails, leaving only the forward wheels touching. If both rudders are placed at such an angle that they both lift and the machine is run at a very high velocity, all four of the wheels will be lifted from the steel rails. This would seem to show that these rudders are efficient as far as vertical steering is concerned. If the machine should break down in the air, it would be necessary to tilt the rudders, when it would fall to the ground without pitching or diving.

(To be continued.)

ANTON RUBINSTEIN.

THE famous musician Anton Gregor Rubinstein died at Peterhof, near St. Petersburg, November 20. The eminent composer and pianist was born at Wechwotynetz, near Jassy, Russia, of Hebrew parents, on November 20, 1829. Anton was a remarkably precocious boy. He made his first concert tour when he was ten years old. He went to Paris, where he made the acquaintance of Liszt, from whom he obtained valuable advice in regard to his studies. Rubinstein gave concerts in England, Sweden, Holland and Germany and in 1845 he went to Berlin to study composition under Dehn. In 1848 he returned to Russia, where the honor of Kammer-Virtuos was conferred on

ANTON RUBINSTEIN.

him. In 1862 he founded the St. Petersburg Conservatory. There was hardly a corner of Europe where the great pianist did not give concerts. In 1872 he visited America, giving concerts in all the leading cities. Of late years he has usually appeared as a conductor of his larger works. He spent most of his time between Dresden and St. Petersburg, in each of which places he had a home. His features were Russian in type. A heavy leonine shock of hair surmounted his massive head. In addition to several symphonies, he composed the following operas: "Nero." "Feromors." "Children of the Heath," "The Maccabees" and "Sulamith." His oratorios were "Paradise Lost," the "Tower of Babel" and "Moses." His chamber music was justly popular. As a pianist he will ever be remembered as one of the greatest who have ever lived. Although he never became a "fad" like Paderewski, the memory of the impression made by his pianoforte playing upon the music lovers of the United States is still remembered by all who heard him.

[FROM THE NINETEENTH CENTURY.]

NEW SOURCES OF ELECTRIC POWER.

ELECTRIC ENERGY DIRECT FROM THE COAL FIELDS.

IN a recent article in the London Times it was stated that, if the history of the present century could be represented by the use of one word, that word would be steam.

Probably the word invention would more adequately represent the source of the great changes in the social and industrial life of this last century; nevertheless, the word steam brings to mind at once the colossal effects that this power-generating agent has produced, crushing out of existence nearly all the other agencies that man relied upon to assist him in his work, and providing in its ensemble of application an equivalent power for work that could not be equaled by millions of able-bodied men.

More than ever, in this era of industrial struggles, cheapness of power is likely to be the principal and all-important factor of value in fixing upon suitable sites for the establishment of new industries. For the production of power for industrial purposes one of three natural agencies is usually employed; e. g., the fall of water; the influence of wind currents; and the development of work by the production of heat by the combustion of coal or other forms of available fuel.

In England the secret of our industrial greatness and, in a measure, the cause of our commercial supremacy, may be revealed in our unrivaled facilities for the production of power by the third agency, or heat power.

Our splendid fuel resources permitted our ancestors to obtain full justice for the fruit of the inventive genius of Watt. Trevithick, Stephenson, Crompton, Kay, Arkwright, and others, enabling our manufacturers to flood the world's markets with the marvelous products of our looms and of our forges, through an era of unexampled prosperity that extended over a quarter of a century.

In this golden period of prosperity our people accumulated enormous wealth, a great part of which is invested in foreign bonds and railway developments. The extent of this wealth will be realized when it is known that in our country income tax is paid on £764,000,000 of foreign government stocks.

This enormous wealth potential could not have been accumulated had we not had the mineral treasures in our coal fields; and every discovery, invention, or scientific application that will assist in increasing the value of these mineral treasures becomes at once of national importance.

A discovery in applied science that deserves to rank with the invention of Watt for the utilization of steam power purposes was the invention by the illustrious Michael Faraday of the dynamo electric generator.

The value of this invention of 1826 was increased beyond all calculation by the accidental discovery, in 1873, of its reversibility.

It appears that the Gramme Electric Company were exhibiting two dynamo electric generators at the Vienna Exhibition for lighting purposes.

One of these machines was in motion, the other idle; a workman, seeing some electric cables trailing on the ground, and thinking they belonged to the second machine, connected the cables to the terminals of this second and inactive machine. To his surprise, the armature of this machine commenced to revolve, proving the reversibility of the dynamo electric machines.

This discovery will have an effect on civilization that cannot be weighed or foreshadowed. Great as have been the influences of the use of steam power on modern life and civilization, compared with the possibilities of electric energy as the method of applying and transmitting power, the influences of steam will become almost trivial.

When it is understood that power can be generated in one locality, and that this power can be transmitted by suitable conductors to distances of over one hundred miles, and delivered with at least seventy-five per cent, of the original power, the possibilities of application of this new agency for transmitting energy may be realized.

This fact of modern applied science, proved, as it was, to the hilt by the famous Lauffen-Frankfort experiments of electrical transmission over 112 miles, has permitted waterfall sources of power to be utilized; and in no country more than Switzerland, where the influence of the magic energy has been most beneficial, and languishing industries in this Alpine region have not only been stimulated, but the interesting and romantic Swiss race has taken time by the forelock in applying to the full the bounty that nature and science have enriched them with, and many a new lucrative industry has been created and is flourishing that would never have existed but for this wonderful electric energy.

The power-producing potential of the mighty Niagara is also being tapped; a large conduit has been constructed near the falls, through which enormous volumes of water swiftly flow, and drive immense power-producing turbines having a total power output of 100,000 horse power.

The enormous power that can be drawn upon for transmission purposes from the Niagara Falls will be understood when it is known that the weight of water that passes over these falls is equivalent to the production of 7,000,000 horse power per hour; so that by electrical transmission a great part of this power required for the industries of North America could be supplied from the falls.

One of the most interesting examples of electric transmission of power is that of Tivoli, near Rome; here the antique and modern engineer join hands.

The water delivered from the old Roman aqueducts at Tivoli drives very powerful turbines and an electric generating plant, and the energy generated is transmitted by four copper cables to the city of Rome, some nineteen miles away, where it is distributed for lighting and power purposes—the water brought by those triumphs of Roman engineering thus serving as a means of lighting the superb monuments of the genius of the old Roman artist-architects.

On the Transvaal, South Africa, electric power distribution projects are either in hand or under consideration for driving gold mining machinery with the power of waterfalls, miles away from the modern El Dorado, on the Banket gold mining fields of the Randt.

Projects are being developed for utilizing the waterfalls of Finland for supplying electric power and light energy for the Russian capital.

Almost everywhere natural sources of power are being drawn upon, and already new industrial concerns are being established to take up the power from the Niagara turbines. It is intended in the near future to transmit the bulk of the power to the centers of industry in the Northern States of America.

When the natural forces of gravity are being drawn upon by our industrial rivals, the pertinent question for us is, Do we in England utilize our own natural resources in a manner such as to command the satisfaction of the progressive engineer? And again, Do we utilize to the full the advantages that electrical phenomena have revealed to us? To both these questions only one answer can truly be given, and that answer is a negative one.

With the exception of the splendid improvement in-

troduced by the illustrious American, George Corliss, there cannot be said to have been any great revolution in the methods of converting heat into work through the medium of steam; but a brilliant innovation has been brought into the commercial field by the German practical scientist's (the late Dr. Otto) invention, by which, and without the intervention of steam, but by the direct combustion of fuel in the engine cylinder itself, heat is directly converted into work. This invention for small powers has had a wide application in recent years; nevertheless, in all our great industrial occupations the practical power agency employed is still the steam engine, and the coal has to be brought to our mills and works from coal pits miles away, by the agencies of cart and railway wagon; and the blackened and dirty, not to say filthy, condition of the buildings and streets of our towns, and the insult to nature by the pollution of our rivers and of the atmosphere with dirty and wasteful industrial effluents, might well increase and bring in the hatred of the lover of art and nature, such as is John Ruskin, against the development of the application of practical science for the convenience and well-being of civilized humanity.

Our cities are almost unfit to reside in, and the natural life of the Zulu or the simple life of the Italian peasant is much to be preferred to that of the English workman, with his daily grinding labor amid the dirty surroundings of our smoke-begrimed industrial centers.

If wealth requires that the beauties of nature should be sullied by the production of effluents that offend all natural laws, better by far that we should have poverty, but with the great wealth of natural purity.

Fortunately, the discovery of the reversibility of the electric generating machine and the possibility of electric transmission of power under very high pressures, has enabled such a complete transformation to be effected in engineering procedure as to deserve the encomiums of Ruskin himself.

With the modern and more scientific method of converting heat into work there is no necessity for the smoky factory chimney, which is a necessary evil of a steam power station.

By the adoption of the new procedure with the electric agent the noise, dirt and danger inseparable from our present steam raising and power plants would disappear, and the present methods of power production would only be remembered as sources of worry and expense to the already harassed manufacturer.

Our large cities of Liverpool, Manchester and Glasgow obtain their water for domestic and industrial purposes from inland lakes miles away.

We have, therefore, splendid municipal criterions for the project of distributing electric energy from the coal fields, a system that would sweep away at once all the disgrace that attaches to the existing methods of steam power production, and which would be a benefit that would be truly national, covering, as it would do, both the manufacturer and the private citizen.

Briefly described, the project is to supply electric power generated in central stations built in the centers of our coal fields to our great industrial centers and to the metropolis itself.

The power station for serving the metropolis would be erected on the Derbyshire coal field; an auxiliary station to serve the Midland Counties would be erected in the Staffordshire coal field.

The electrical trunk lines would serve the larger towns en route, including Derby, Nottingham, Birmingham, Leicester, Northampton and Bedford. Distributing, transforming and storage stations could be erected near the metropolis.

The different metropolitan and suburban electric light stations could be supplied with energy for general distribution. Electric railways and other power stations could also be supplied.

Larger power consumers could be supplied with power direct.

Each vestry not already supplied with an electric generating plant could be invited to put down a distributing system and a receiving station.

The electric energy could be sold to the different distributing companies at such a price as to enable the power to be supplied to the light and power consumer at an economic and attractive figure, or at a little over one penny per kilowatt hour.

The industrial centers of Lancashire, Yorkshire and Cheshire would be supplied with electric energy generated in two coal field stations, respectively near Wigan and Barnsley.

The cost of power to the small factory'owner need not exceed £5 per 3,000 working hours of one actual horse power of energy. In the metropolis, this energy by the present system will cost between £9 and £12.

This electrical power agency permits the starting or stopping of the plant by the mere turning of a switch or the pressure of a button.

While the power plant is not actually doing work there is neither serious loss nor anxiety involved. The power user is not troubled with boiler insurance or the smoke nuisance inspector; he may simply hire the electric motors, and when he decides to remove his manufacturing appliances, he has merely to return the hired motors; whereas a steam power plant with its chimney cannot, except with a great sacrifice, be removed.

If the system is carried out entirely, each machine can be driven independently by its own motor; consequently, the expensive items of belting, shafting and pulleys are almost entirely reduced.

Instead of having to run a 100 horse power engine to develop 20 horse power, which is with steam power an hourly possibility, with electric driving only the power required is produced, and the factory owner, or the power user, only pays for the actual power he absorbs in his work.

The centralization of the plant in the coal fields permits the recovery of all the valuable chemical constituents from the coal, which are not recoverable by the small steam power systems in use. One of these constituents, sulphate of ammonia, is of proved value as a manurial agent, and if this value were recovered from the coal raised from English pits, there would be no necessity to ransack the fields of Chile and Peru for nitrates.

The centralization of power production would permit such an application of automatic or labor saving machinery as to make the plant independent of the effects following the differences that occur between Capital and Labor.

The method of transforming the fuel into power could be effected in such a perfect manner as to convert, as far as practicable, all the available heat into work, and produce such an efficiency as will be understood by the ratio of 0·75 lb. of combustible to one actual or available horse power of energy for the period of one hour.

The average consumption by existing steam plants cannot be taken as less than 5 lb. of fuel for the same actual power during the same time.

In the transmission of this electric energy to the Midlands and the metropolis there will be a loss of, say, 33 per cent., so that the 0·75 lb. will be increased to 1 lb. of combustible per actual horse power per hour.

Compared with the transmission of the coal by cart and rail to satisfy the same power requirements in the metropolis, it will be realized that the equivalent of one ton of transmitted electrical power delivered in London is equal to three tons of rail-transmitted steam coal power, so that the relative cost of the two powers is, by the weight test, clearly in favor of the electrical power.

Further comparing in other respects the two systems of power transmission—the railway and the electric cable one—the permanent way of railways requires constant renewal, whereas the electric copper cable will be as good in twenty-five years as when first established. The recent variation in the value of copper, of which the cables would be formed, has not been very serious, and there is every reason to believe that the value of copper will be an ascending one.

As an investment, copper laid down as cables for transmitting energy power from the coal fields is as safe as if the copper were in the Bank of England.

Therefore the cost of laying down the cables, per se, should be covered by the issue of separate debenture shares at a little above the average bank rate of interest.

In the transmission of coal by rail the same coal wagons have to return the entire distance empty, because coal wagons are not suitable for any other kind of goods traffic.

The wear and tear of coal-carrying railway stock is very great, and with the comparatively low rates charged for this traffic, considering its wear on the permanent way, it is questionable whether it is a desirable traffic for railway companies to have.

By the time the steam coal, costing, say, 4s. 6d. at the pit mouth, reaches the London terminus its cost has been increased to from 10s. to 11s.; the merchant's profits, coupled to the carting charges, brings the cost to 13s. at the factory or other consumer's stores.

Analysis shows that most coals contain from 5 to 10 per cent. of incombustible residuum, known as ash and clinker; it follows, therefore, that for every 1,000,000 tons of coal brought to London, from 50,000 to 100,000 tons of incombustible matter is carried.

This waste of carrying power, as well as the waste of coal in transit, will, by electric transmission, be entirely avoided.

The cost of the electric transmission cable and wayleaves, divided, as it would be, with the Midland consumers, would not fall heavily in the metropolitan area.

The trunk cables would be either suspended from poles a la telegraph, or be placed in underground trenches or conduits; there would be little, if any, greater difficulty in fixing up the power lines than with the telegraph or telephone ones.

For the transmission of 10,000 horse power three bare conductors for positive and three for negative currents would be used, equipped with oil insulators.

Lightning arresters would be arranged where the cables are overhead.

The pressure of the current (30,000 volts) would be transformed down to 2,000 volts at the Midland and metropolitan receiving stations, for the convenience of the local metropolitan companies, who can transform the pressure at their own stations down to their normal working and distributing one.

The distribution of the electric energy to the various Greater London electric supply companies at a price of 2¼d. per kilowatt or electrical horse power would permit them to sell the current to their consumers for 3d. to 4d. per kilowatt, instead of 7d. to 8d. charged by the Metropolitan Company for this equivalent of energy.

It would be impossible in the limits of this article to define with any degree of completeness all the benefits that would follow the application of that transcendent gift to man involved in the possibility of the long-distance electric transmission of energy that recent science and discovery have unearthed from nature's secret stores.

The developments that have followed the invention of that imperfect instrument for converting heat into work by the agency of steam—the steam engine—have been of untold advantage to the human race, but the application of modern practical thermodynamics and electro-technics is destined to produce a still greater change and amelioration in the conditions of commercial, industrial and home life.

Electrical energy is almost daily being applied to new directions, and with almost marvelous results; so that, besides providing the primum mobile to our industrial ateliers and providing a hygienically perfect illuminant, it gives the manufacturer the power of welding and annealing bars without a forge furnace, and enables him to melt both steel, iron, copper and brass rapidly and conveniently.

He can produce aluminum, chlorine, caustic soda; effect bleaching and tanning by electrolysis; and by the phenomenon of varying electrical resistance of different conductors he can effect cooking, evaporating and heating operations.

To the florist it offers a means of accelerating floral growth.

The energy can be utilized for ventilation, for actuating knife-cleaning, sewing and laundry machinery.

The electric energy generated in the coal field stations and transmitted to the industrial centers of England and to the metropolis would enable the magic influence to be distributed to consumers at a price within the reach of rich and poor alike—a benefit for all and every one. B. H. THWAITE, Civil Engineer.

II. ELECTRICITY FROM PEAT.

The Irish question is for the moment in the back ground, but the Highland question is coming again to the front, and Lord Rosebery, speaking at Inverness last September, when opening a bazar for the encouragement of native industries, declared the intention of the government to deal with it next session. In this article I do not propose to consider the political aspects of the question, but to indicate a possible way of helping the Highlands, and also Ireland, by means of private enterprise.

It is plain even to a passing tourist that much of the discontent in the Highlands and West of Ireland is, at bottom, due to the character of the country. As he surveys the desolate moors and mountains, with their crags and waterfalls, he may well ask himself: In a civilized age, what can be done with a land so devoid of natural resources, of raw materials? According to the popular creed, "whisky, herrings, and crofters" are the principal productions of the Highlands. To these may be added slate and paving stone, timber, good air, wild scenery, and game attractive to visitors, and also sheep and wool work. There is another product not unworthy of mention, one we are too apt to forget, although it is the best that any soil can produce, and that is—men. It must be owned that the Highlanders are a fine breed of men. Everything goes to prove that, mentally and physically, they are among the ablest men in the empire. There are persons, the victims of their own ignorance and prejudice, who affect to sneer at them as an inferior race; but neither personal acquaintance with the Highlanders, nor the lessons of history, nor the results of anthropology, will bear them out. Politicians, to serve their own ends and bias the electorate, endeavor to stir up the dying embers of racial spite by calling them "Celts" and "foreigners," akin to the French, and the natural enemy of the "Anglo-Saxons;" although it has been perfectly well known to anthropologists for many years that the Highlanders are not Celts at all, except in name, but a mixed people, practically the same as the Lowland Scotch, and similar to the rest of the nation both in blood and origin. By actual measurement of their bodily strength, and by their conspicuous success at home and abroad in every walk of life, civil, political, and military, they appear as the most vigorous branch of the whole British race. Evidently the future belongs to the Highlanders. At the very least they will fight our battles and reinvigorate our more exhausted stock. Yet there are statesmen who can find no better remedy for the Highland trouble than to ship them out of the country. We are asked to raise money to export the flower of the nation, and at the same time we import all manner of destitute and diseased aliens. What should we say of a man who drained away his best blood and supplied its place with bad? In plain English, we should call him a madman.

We cannot spare the Highlanders, and something should be done to keep them in the country. Can we not employ electricity, which has changed the prospects of so many places, to the advantage of the Highlands? The fishermen of Loch Fyne are trying to get a light railway from Strachur to Kilmun, in order to place their delicious fish on the Glasgow market on the morning, and the London market in the evening, of the day on which they are caught, and all who have tasted a genuine fresh Loch Fyne herring will devoutly wish them every success; but they must wait until the government assist them. Here, then, is a case in which electricity might play a part, for there is water power in the neighborhood to drive the trains. Some time ago I was talking of this very matter with Professor George Forbes, F.R.S., the distinguished consulting electrician to the Cataract Construction Company, of Niagara, and perhaps the highest living authority on the transmission of power by electricity, and he asserted that he would undertake to run all the railways of Scotland by means of the water power which is now running to waste. Apart from the railways, some of the electric power might be applied to industrial purposes if there were raw material on the spot.

There is, however, another source of prosperity in the Highlands and Ireland, which has been too much neglected—namely, peat. In peat we have at once a fuel and a raw material, and what I desire to point out is that, by burning it in engines, we can obtain not only the power required to manufacture the raw peat, but also a supply of electricity for distribution.

Peat, as many people know, is altered vegetable matter, consisting largely of bog mosses and hill grasses. It is formed in old lake beds, mountain tarns, marshes and fallen forests. Of recent origin, its growth is comparatively rapid. Dugout canoes, weapons of the Bronze Age, even Roman coins and roads, are found beneath it. The peat moss of Kincardine flourishes on the site of an old oak forest, which has been felled by hand, for the marks of the ax can be seen on the stumps eight feet below the surface. In the seventeenth century a storm on Loch Broom, in Rossshire, leveled a forest, and in less than fifty years afterward peat was dug on the site. Peat beds sometimes yield bog oak and bog iron ore, both of which are valuable, and the peat itself, when analyzed, gives about 60 per cent. of carbon, 33 per cent. of oxygen, 6 per cent. of hydrogen, and 1 per cent. of nitrogen. The amount of ash varies with the purity of the peat from below 1 per cent. to over 60 per cent., and consists of sand, clay, oxide of iron, and sulphuric acid, with traces of lime, soda, potash, and magnesia.

The peat beds of the United Kingdom are both numerous and rich, but strange to tell, they have not even been surveyed, and we can only form a rough estimate of their extent. According to Mr. P. F. Nursey, ex-president of the Society of Engineers, there are no fewer than six million acres of peat in the country, having an average depth of 12 feet, and capable of yielding 3,500 tons per acre of dried peat, or twenty-one billion tons in all.

In England, one of the most notable accumulations is Chat Moss, near Liverpool. In Scotland there are many of all sizes, but the Moor of Rannoch, celebrated in Mr. Stevenson's Kidnapped, is perhaps the largest; and in Ireland the best known is the great Bog of Allen, which is said to comprise 288,500 acres of peat, having an average depth of 25 feet. The total extent of peat in Ireland is cast at 2,830,000 acres, or nearly one-

seventh of the whole area of the island, and of this 1,570,000 acres are of the best "red peat." As the value of raw peat is to that of coal as about 1 to 6, the total amount of peat fuel in Ireland is equivalent to 470,000,000 tons of coal, which at 12s. a ton represents £280,000,000 sterling.

There is also much peat on the Continent, and it was probably with a view of helping Ireland through her peat beds that the government of Lord Salisbury in 1892 issued a circular to her Majesty's representatives at Paris, the Hague, Copenhagen, Stockholm, St. Petersburg and Berlin, asking for information as to the peat industries in the northern countries. The immediate result of the inquiry was a series of valuable reports, published in 1893, which may be studied by all who are interested in the utilization of peat. They show that Germany, Holland and Scandinavia, in particular, are making the most of their peat supplies, therein affording us an example which we might do well to follow.

The turf moors or Torf moore of Germany occur chiefly in Prussia, and belong to the government. They are worked either by the forestry department or leased to tenants, who are required to prepare the underlying soil for cultivation. The peat is cut and dried in the open air during the summer, then sold as fuel, or made into "litter" for bedding for cattle, or turf mould (Torf-mull) for disinfecting purposes. The fibers are also woven into a coarse cloth, or ground into paper pulp. Moreover, the peat is distilled into coke and charcoal, and a variety of chemical products in general use.

The fuel is consumed in the locality for heating brick kilns, baking ovens, and so on, as the cost of freight forbids it to compete with coal at a distance; but a great part of the litter is exported, even as far as America, and, incredible as it may appear, 1,200 tons a year, or one-fourth the entire output of Oldenburg, is actually sent to Great Britain and Ireland, where we have so much unused peat of our own.

In Friesland and other parts of Holland the "black turf" is made into fuel for brick kilns, litter for stables and mould for mixing with sewage. Some of it is exported to Bremen, Brunswick and Belgium, and it is stated that 280,000 tons of the fuel, worth £133,000, are annually consumed throughout the Netherlands. The Dutch canals facilitate the transport of the peat, and, as the subsoil of the moors is always cultivated after the peat is lifted, the barges that take away the peat bring back manure for the ground. At Groningen, for instance, all the sewage of the city is applied to the reclamation of the turf moors. In Denmark, where there is no great supply of peat, it is chiefly used by the peasants as fuel, or as bedding in the dairy farms. In Sweden, on the contrary, there are bogs extending for hundreds of square miles, and of late years over 600,000 acres of the moorland have been brought under the plow. The peat is prepared as fuel, and largely consumed in making iron, glass or brick, either alone or mixed with coal and fir cones. In southern Sweden there are factories solely engaged in manufacturing peat fuel for sale, as its use in steadily increasing, and some 30,000 tons a year are employed in metallurgical operations. In southern and central Sweden there are some twenty factories for preparing peat litter and mould, each factory turning out from 15,000 to 30,000 bales a year, fetching about 2s. apiece. The mould is used for gardening in Sweden, while stuffing for mattresses or furniture, and surgical bandages are made from the white moss of the moors. In France the peat is moulded into "briquettes" with tar and resin, teased into litter, or woven into fabrics which are used in the army, its barracks and hospitals as blankets, mattresses, and saddlecloths, or for stuffing cofferdams and certain parts of machinery.

According to Mr. Nursey, peat fuel, made by removing the fibers and condensing it, is not more expensive than coal at the pit mouth. It burns freely in the furnace, requiring little draught, and yields more gas and heat than coal, thus enabling steam to be got up sooner and more work to be done. It is free from the nuisance of sparks and clinkers, sulphur and soot, and the smoke is rather healthy and agreeable than otherwise, it being esteemed a remedy for consumption. Lampblack, tar and aniline dyes, naphtha, paraffine and other hydrocarbons, lighting and lubricating oils, illuminating gas, which is apparently the coming fuel, alcohol, vinegar, salts of ammonia, acetate of lime, and soda are also among the products of distillation.

Peat litter is a more sanitary and comfortable bedding for animals than straw, and makes a better manure. Peat dust or mould is an excellent deodorizer and absorbent, which is employed in earth closets, slaughter houses, sugar factories, and elsewhere. It is also good for packing fish, fruit, and other perishable freight, and, being a nonconductor of heat, for lining the walls of rooms and ice cellars. Peat fiber is made into celluloid, roofing, and match wood, as well as carpets, cloth, and paper pulp.

In southern Bavaria peat fuel is burnt in locomotives, and would evidently suit our underground lines. Tried on a river steamboat by Mr. B. Fothergill, it was found to last twice longer than coal and give the same speed. Briquettes made with tar and coal dust or resin are coming into favor for household use even in England, thanks to the Peat Fuel Company, of London, and they will burn in any furnace for coal or wood. Peat coke and charcoal, which fetch as much as wood charcoal, are in request for smelting, puddling, and forging iron, as they are free from sulphur, which makes it brittle, and also for smelting lead, blowing glass, making gunpowder or fireworks, and other chemical purposes. Bitumen got by distilling the peat is also utilized in paving streets.

A fuel as well as a raw material, peat can supply the power required to coke, distill and manufacture itself. For convenience and economy the associated industries ought to be carried on at the peat beds, which should be connected by rail or water with the best markets. We are now witnessing the rise of a new industrial city at Niagara, in which the machinery will be driven by electric power derived from the falls, and we may yet see the Bog of Allen or the Moor of Rannoch supporting settlements and factories for the utilization of peat. The soil reclaimed by the removal of the peat could be brought under cultivation with fertilizers made from the peat, or the sewage of towns—for example, the muck now dredged from the Clyde and flung into the sea. It is also a question for horticulturists whether fruit and vegetables could not be forced under glass on a large scale with the help of peat fuel, peat mould, and the electric light in thick weather, after the manner of the late Sir William Siemens. Moreover, just as in the case of Niagara, where electric power is to be sent by wire to the city of Buffalo, so in the Highlands and Ireland it could be distributed to work railways, and to the nearest towns or villages; and Oban, Inverness, or even Glasgow, might derive both light and energy from what is now the dark, inert, and dismal Moor of Rannoch. J. MUNRO.

DISTRIBUTION OF LIGHT FROM ARC LAMPS.

By RANKIN KENNEDY.

THE light is thrown out from the arc in a continuous current circuit, principally in the form of a cone having its apex at the arc and its base on the ground;

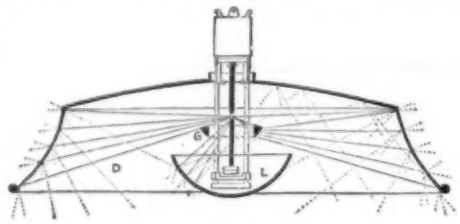


FIG. 1.

this is a favorable circumstance, and is taken advantage of to the fullest extent in street lighting by arc lamps.

For interior illumination the lower carbon is made sometimes the positive carbon, and the cone of light thrown up on to a white ceiling, or a white disk above the lamp, a method first used at the 1880 Paris Exhibition by Jasper, in lighting the art gallery.

An arrangement by Siemens & Halske for the same purpose consists of a diffuser hung over an ordinary lamp. This diffuser is like a reflector in shape, and is about 3 feet 6 inches or 4 feet in diameter at the mouth, and is white painted inside; it is shown at D, in Fig. 1.

A bowl-shaped reflector, or, in other words, a common enameled iron bowl, white inside, L, is hung below the lamp and serves a double purpose, reflecting light up into the diffuser and receiving any ash or carbon falling from the arc.

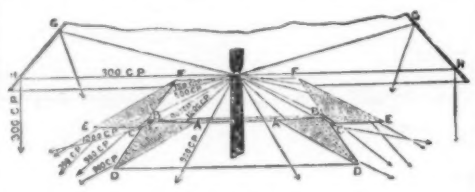
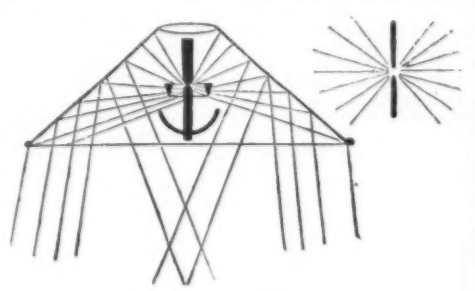


FIG. 2.

Such an arrangement is so far quite old, and is used in photographic electric lamps by Gwynne.

But a new and interesting addition for street lighting is shown at G, a ring of polished glass of triangular section. This ring receives the most intense cone of light from the arc, and deflects it on to the white surface of the diffuser, as shown by the divergent lines; with this arrangement a beautifully uniform illumination is produced. The lamp, of course, must be a focusing lamp; the glass ring is best built up of four or six segments of glass held in a light metal frame; the diffuser is umbrella shaped and made of canvas on a wire frame, and painted inside with lead white. The whole arrangement is light and cheap and easily applied to any focusing lamp.

An arrangement like this is far more rational and superior to the insane practice of using semi-opaque globes over arcs in street lighting; these simply cut



FIGS. 3 AND 3A.

off from 30 to 60 per cent. of the light produced, and do not in any way assist the diffusion or distribution of the light. It can never be accepted as good sense to generate at great expense a powerful light of, say, 600 candle power, and then to carefully cut off 200 candle power of it in absolute waste. Yet that is what is done in every arc lamp with a semi-opaque globe on it.

In this arrangement, Fig. 1, the arc is about 8 or 9 inches from the upper surface of the diffuser, which is altogether about 18 inches deep.

Prof. Anthony, who is a prominent authority on arc lighting in America, proposes another scheme for distributing light from arcs.

Fig. 2 illustrates his method; two rings of glass, A B C, D E F, of cross section, shown fixed with the arc on the level of the upper edge, H, G. H, G is a reflector above the arc, which receives the upward-thrown light and sends it to light up the space immediately below the arc. By means of the prisms the strongest rays are sent furthest off, as will be seen by following the path of the 1,200 C. P. ray in Fig. 2.

This is rather an elaborate arrangement, but still as it would give at least four times more light, evenly distributed, compared with the semi-opaque globe, it may be cheaper in the end to use it.

The idea is not to waste about half of the light in an endeavor to soften it, but to screen off the actual light and diffuse or reflect it from a large white surface.

An alternating current arc requires a very different form of rings of glass, and also a different form of diffusing surface. A plain cone is best for this purpose, as the light is thrown from the alternating arc in a diverging ring as in 3a.

The usual arrangements of large diffusers are very hideous looking affairs, but where arc lighting is to be adopted on any large scale it is easy enough to make them both effective and artistic with the aid of the architect.—The Electrical Review.

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